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MISSOURI RIVER COMMISSION 420

CALIFORNIA DÉBRIS COMMISSION 421

BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

Under authority of special acts of Congress.—(1) Bridge of the East Liverpool Bridge Company across Ohio River between Chester, W. Va., and East Liverpool, Ohio, (2) bridge of the Pittsburg, Monongahela and Wheeling Railroad Company across Monongahela River at Monongahela City, Pa., (3) bridge of the village of Osceola, Wis., across St. Croix River, (4) bridge of the Galveston, La Porte and Houston Railway Company across Buffalo Bayou, Tex., (5) bridge of the Oregon Central and Eastern Railroad Company across Willamette River at Albany, Oreg., (6) bridge of the Ohio River Bridge Company across Ohio River at Rochester, Pa., (7) bridge of the Kansas City and Atlantic Railroad Company (Chicago, Kansas City and Texas Railway Company) across Missouri River at Kansas City, Mo., 422; (8) bridge of the St. Louis, Avoyelles and Southwestern Railroad Company across Bayou Des Glaises, La., (9) bridge of the Wisconsin and New Duluth Bridge Company across St. Louis River, Wis., (10) bridge of the New York and New Jersey Bridge Companies across Hudson River, (11) bridge of Aitkin County, Minn., across the Mississippi River at Aitkin, (12) bridge of the Pittsburg and Mansfield Railroad Company across Monongahela River near Ferry street, Pittsburg, Pa., (13) bridge of the city of Columbia, Ala., across Chattahoochee River, (14) bridge of Pulaski County, Ark., across Arkansas River at Little Rock, 423; (15) bridge of Knox County, Tenn., across Tennessee River at Knoxville, (16) bridge of the West Braddock Bridge Company across Monongahela River at Rankin, Pa., (17) bridge of the Hammond and Blue Island Railroad Company across Calumet River, Ill., (18) bridge of the Butler and Pittsburg Railroad Company across Allegheny River near Pittsburg, Pa., 424.

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UNITED STATES ARMY.

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UNITED STATES ENGINEER OFFICE,
Montgomery, Ala., July 13, 1896.

GENERAL: I have the honor to forward herewith the annual reports of river and harbor works under my charge.

* * * * * * *

Very respectfully, your obedient servant,

F. A. MAHAN,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

O 1.

IMPROVEMENT OF APALACHICOLA BAY, FLORIDA.

DESCRIPTION.

Apalachicola Bay is a long, broad, and shallow sheet of water on the south coast of Florida. It is separated from the Gulf of Mexico by St. Vincents Island, Sand Island, and the western half of St. Georges Island. The bay, when continued to the eastward, forms St. Georges Sound, which is separated from the Gulf by the eastern half of St. Georges Island, by Dog Island, and Dog Island Reef.

The line dividing Apalachicola Bay from St. Georges Sound runs from Cat Point, on the north shore, to Bulkhead Point, on St. Georges Island. On this line is found Bulkhead Shoal.

Access to Apalachicola Bay can be had through West Pass, between St. Vincents and Sand islands. This pass is rarely used, as there is no good anchorage inside.

The entrance to St. Georges Sound is through East Pass, between St Georges and Dog islands.

Apalachicola Harbor is the deep water just inside of East Pass and north of Dog Island.

ORIGINAL CONDITION.

Apalachicola River enters Apalachicola Bay at about the middle of its north side. A bar exists at the mouth of the river. The depth of water on it was originally but 3.5 feet. The width of the bar between the 8-foot curves inside and outside varies; it averages 7,000 feet in round numbers.

The depth of water across Bulkhead Shoal was originally less than 4 feet.

PROJECTS OF IMPROVEMENT.

The report of the examination of Apalachicola Bay is to be found in the Report of the Chief of Engineers for 1879, page 823. This report recommended that a channel 100 feet wide and 11 feet deep should be dug through the bar at the mouth of the river. If the results obtained by this cut were such as to warrant its enlargement, it was recommended that the width be increased to 200 feet. This project was approved; the cost was estimated at $100,000.

A survey of the mouth of the river and of the eastern part of Apalachicola Bay was made in 1891. As the result of this survey, the above project was again recommended, and to it was added the recommendation that a channel 9 feet deep and not less than 100 feet wide should be cut through Bulkhead Shoal.

APPROPRIATIONS.

The following amounts have been appropriated from time to time for this bay:

March 2, 1833	$8,700	August 11, 1888	$20,000
July 4, 1836	10,000	September 19, 1890	20,000
March 3, 1839	9,900	July 13, 1892	20,000
June 14, 1880	10,000	August 17, 1894	15,000
March 3, 1881	10,000	June 3, 1896	12,000
August 2, 1882	25,000		
July 5, 1884	10,000	Total	182,600
August 5, 1886	12,000		

These appropriations were divided into two periods, separated by an interval of forty-one years, viz: From 1833 to 1839, $28,600; from 1880 to 1896, $154,000.

OPERATIONS TO JUNE 30, 1895.

The channel through the bar at the mouth of the river nas never been obtained as recommended, owing to insufficiency of appropriations. The width has never exceeded 100 feet; the depth has never exceeded 9.5 feet, as against the 11 feet proposed.

The first cut was made during the winter of 1881–82. It was begun at 11 feet inside the bar, and the depth of 11 feet was maintained for a length of 5,748 feet. Of this length, 1,967 feet was 60 feet wide; 3,781 feet was but 30 feet wide. During 1883 the 30-foot cut was widened to 60 feet and extended to the 9.5-foot curve outside the bar; an additional

cut 15 feet wide was made through the bar. Work done during 1884 left the channel in the following condition: Average depth, 9.5 feet; total length, 6,060 feet, of which 5,200 feet was 75 feet wide and 860 feet 60 feet wide. During the spring of 1885 the cut was partly reopened, it having filled up to an available depth of 6 feet. The reopening was made 4,177 feet long, 60 feet wide, and 9.5 feet deep. During 1887 and 1888 the cut was reopened with the following dimensions: Length, 3,635 feet; width, 60 feet; depth, 9 feet.

An examination made in March, 1889, showed that the cut had shoaled to 4 feet in depth. The cut was reopened between November, 1889, and May, 1890, to a depth of 8 feet, with a length of 6,000 feet and a width varying from 80 to 90 feet. The cut was again reopened between November, 1892, and April, 1893, with these dimensions: 5,350 feet long; 120 feet wide at inner end and 100 feet wide at outer end; 8 feet deep.

An examination made in April, 1894, showed that the channel had shoaled, since the reopening in 1892–93, 2.5 feet for a length of 2,000 feet near the inner end.

A straight cut, 4,000 feet long, 120 feet wide, and 9 feet deep, was made across Bulkhead Shoal in October, 1891, to February, 1892. An examination of this cut made in June, 1895, shows no filling up, and none has been reported since then by those who are using the cut constantly.

OPERATIONS DURING FISCAL YEAR ENDING JUNE 30, 1896.

The cut through the bar at the mouth of the river was made under a contract with the Rittenhouse Moore Dredging Company, of Mobile, Ala., approved June 24, 1895. Work began on January 7, 1896, and ended February 29, 1896, the appropriation being exhausted. The cut made was 4,930 feet long, 100 feet wide, and 8 feet deep at low water. The conditions of work were unfavorable, as the deepest cut was only 3.5 feet, with a shoalest cut of 0.7 foot. The average depth was 2 feet. The materials removed varied from soft mud to firm sand. The volume removed was 54,253 cubic yards.

The experience gained by this dredging confirms that of former years, viz, that to maintain the channel through the bar at the mouth of the river at its present dimensions requires the removal of 50,000 to 60,000 cubic yards of material annually.

What the result might be if this channel were ever once opened to its full dimensions it is impossible to say. The project for opening the bar at the mouth of the river has never been carried out.

CONDITION OF IMPROVEMENT JUNE 30, 1896.

A brief examination made at the end of the fiscal year seems to show that the cut through the bar has begun to fill up again, although it is less than four months since the last dredging was done.

The channel across Bulkhead Shoal shows no filling, although more than four years have passed since it was finished.

RECOMMENDATIONS AND ESTIMATES.

The commerce of Apalachicola demands a deeper and wider channel. Past experience has shown that the shallow channels dug heretofore (the only ones which the meager appropriations have permitted) have filled up very soon after being finished. It is possible that a wider and deeper channel, say 200 feet wide and 11 feet deep, might stand a better chance for remaining permanent. Such a channel would require the removal of

200,000 cubic yards, in round numbers, of mud, at a cost of $40,000. A longitudinal training wall along the left bank of the river might be of material assistance in keeping the channel open. Whatever improvement may be adopted, it seems clear that more or less dredging will have to be done every year.

An appropriation of $40,000 can be expended judiciously on this work during the year ending June 30, 1898.

Money statement.

July 1, 1895, balance unexpended	$14,796.61
Amount appropriated by act of June 3, 1896	12,000.00
	26,796.61
June 30, 1896, amount expended during fiscal year	14,526.16
July 1, 1896, balance unexpended	12,270.45
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	40,000.00

DEPOSIT OF BALLAST IN APALACHICOLA BAY AT APALACHICOLA, FLA.

APALACHICOLA, FLA., *January 22, 1896.*

DEAR SIR: As there has been a great deal of trouble and annoyance caused lately by the discharging of ballast, the shippers of Apalachicola not wishing to comply with the State law or with the rules and regulations of the harbor of Apalachicola, you would confer the pilot commissioners of the harbor of Apalachicola, Franklin County, Fla., a great benefit not only for themselves, but for the harbor of Apalachicola, by sending a man capable of defining the harbor lines or selecting a proper place for all vessels to discharge their ballast so as not to injure our harbor, as there is no ballast wharf at present in our port. We had an interview with the United States district attorney, and he recommended us to communicate with you. There is at present in our port the United States steamer *Fish Hawk*, of the Fishery Department, locating oyster bars and having a general survey of our bay, and we think the captain of said vessel would be the proper person to locate ballast ground, under your instructions, with but very small expense to the Government, as they are already here in the harbor. By giving this your earliest attention you will oblige the pilot commissioners of Apalachicola, Franklin County, Fla.

Very respectfully,

[SEAL.] JOS. DALY,
President of Board of Pilot Commissioners.

Attest:
R. COLLINS, *Secretary.*

Hon. DANIEL LAMONT,
Secretary of War.

[Second indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
January 29, 1896.

Respectfully referred to Maj. F. A. Mahan, Corps of Engineers, for report.

If, in Major Mahan's opinion, the establishment of harbor lines at this locality is essential to the preservation and protection of the harbor,

he will please prepare and submit to this office for action a map showing the harbor lines recommended for adoption. He is requested to consult personally with parties interested in navigation and in the dock property and prepare a project showing a system of harbor lines which will, if possible, be satisfactory to the interests of navigation as well as to the owners of the land along the river front.

By command of Brig. Gen. Craighill:

A. MACKENZIE,
Lieut. Col., Corps of Engineers.

[Third indorsement.]

U. S. ENGINEER OFFICE,
Montgomery, Ala., February 22, 1896.

Respectfully returned to the Chief of Engineers, United States Army, as directed, attention being invited to the accompanying report.

F. A. MAHAN,
Major, Engineers.

[Fourth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
March 9, 1896.

Respectfully returned to the Secretary of War.

The board of pilot commissioners of Apalachicola, Franklin County, Fla., requests that a locality be designated in the harbor at Apalachicola where all vessels may discharge ballast without injury to navigation interests.

The subject has been given careful consideration by Major Mahan, who submits the accompanying report, dated the 22d ultimo, with the opinion that there is no better location for depositing ballast than that defined in red upon the map* herewith, along the north side of Dog Island, in St. Georges Sound.

Concurring in the views and recommendations of the local officer, and inviting attention to the terms of section 6 of the act of Congress of August 17, 1894, whereby the Secretary of War is empowered to define the limits within which deposits of the character mentioned may be made, I recommend that the place selected by Major Mahan for deposit of material be approved by the Secretary of War and that the Secretary place his approval both upon the tracing, which has been prepared for his signature, and upon this report.

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

[Fifth indorsement.]

WAR DEPARTMENT,
March 11, 1896.

Approved as recommended by Major Mahan and the Chief of Engineers.

DANIEL S. LAMONT,
Secretary of War.

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* Not printed.

REPORT OF MAJ. F. A. MAHAN, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Montgomery, Ala., February 22, 1896.

GENERAL: In accordance with the second indorsement, dated January 29, 1896, I went to Apalachicola, Fla., arriving there on February 13, 1896.

Immediately upon receipt of the communication I wrote to the collector of the port of Apalachicola to inform him of the date of my visit, and to request him to let it be known that I should be there and that I should be glad to hear any expressions of opinion in the matter. I wrote subsequently to Mr. Lynn, one of the pilot commissioners, to the same effect.

I met at Apalachicola four of the pilot commissioners, two pilots, and two or three timber dealers. The matter of the communication was thoroughly discussed.

Apalachicola Bay is a broad, long, and shallow sheet of water on the south coast of Florida, bordering on the Gulf of Mexico. Its boundaries are not very clearly defined. They may be described thus (Coast and Geodetic Survey Chart 183): On the north, a line drawn from St. Vincent Point, on St. Vincent Island, to Green Point, on the shore of the mainland; thence eastward along the shore to the mouth of St. Marks River; on the east, a line drawn from the mouth of St. Marks River to Cat Point, and thence to Bulkhead Point, on St. Georges Island; on the south, St. Georges Island as far as New Inlet; on the southwest, west, and northwest, St. Georges Island west of New Inlet, Sand Island, and St. Vincent Island.

Access can be had to Apalachicola Bay through West Pass, which lies between St. Vincent and Sand islands. Vessels come this way rarely, as there is no good anchorage inside.

Eastward of the bay lies a body of water known as St. Georges Sound (Coast and Geodetic Survey Chart 182). It is separated from Apalachicola Bay by a shoal of which the axis is nearly coincident with the line from Cat Point to Bulkhead Point. This shoal is known locally as Bulkhead Shoal. It is so called in various reports of the Chief of Engineers relating to this harbor.

St. Georges Sound is separated from the Gulf of Mexico by St. Georges Island, Dog Island, and a long shoal known as Dog Island Reef.

The entrance to the sound is through the East Pass, between St. Georges and Dog islands.

What is known locally as Apalachicola Harbor is the deep water inside of the East Pass and to the northward of Dog Island. This island is of irregular shape. The side next the Gulf is a fairly smooth curve for a distance of about 5½ miles from the west end, when it turns abruptly to the north. The western end of the island is a sand spit about 1½ miles long. On the north side of the island are two bights, one in rear of the sand spit, the other in rear of the island proper. The one in rear of the sand spit is called the loading anchorage; the other is the ballast anchorage. The ballast anchorage is the place where vessels coming in ballast to the port have always been discharged until within a very short time.

It is not considered that any harbor lines are required other than what is suggested further on.

An act was passed by the legislature of the State of Florida changing the whole method of unloading ballast. This act was approved May 15, 1895. It applies to all harbors in the State of Florida. I have

asked for a copy of this act. I have not received it yet. The requirements of the act will have to be given from notes made from a copy which was shown to me in Apalachicola.

Before any ballast of a promiscuous sort can be deposited it is necessary—

1. That a bulkhead or an inclosure be built of clean stone, its top to be 2½ feet above high water and of such thickness and construction that no material shall be able to sift or leak through.

2. That it be built of piles set close, not more than 12 inches between centers, with a cap on top and waling piece in front, the top 2½ feet above high water.

3. That it be built of piles set not more than 4 feet between centers, with a waling piece at top in front and back, with a second piece at the back lower down; two thicknesses of sheeting piles to be driven, breaking joints, against the back walings, the top 2½ feet above high water.

Whichever of these forms of bulkhead or inclosure is used, it is necessary that it be connected with the shore by means of a permanent wharf.

The difficulty encountered by the pilot commissioners arises from the State law. No bulkhead or inclosure exists at Apalachicola; consequently no ballast may be deposited within the limits of the harbor. No funds are at the disposal of the commissioners wherewith to construct any such inclosure or bulkhead, or to build a permanent wharf to the shore. Some disposition must be made of the ballast when vessels come in seeking a cargo. The pilot commissioners wish to send it outside, to the southeastward of Dog Island.

There exists here the same trouble which is found at other parts of the country. The harbor is not considered by many persons. The lighters on which ballast has to be removed are dumped where the persons in charge of them choose. The harbor master is unable, through the lack of funds wherewith to do his work, to control this. Many of the shippers seem to care little, so far as I can learn, what is done. If they can make their own shipments now, they do not care for the future.

There is no conflict between the United States law and that of the State of Florida. The former authorizes the Secretary of War to say where the ballast may be deposited; the latter says how it is to be done. The latter takes the matter from where the former leaves it.

I forward herewith, in a separate package, a blue print of a tracing from charts 182 and 183, United States Coast and Geodetic Survey. On the north side of Dog Island will be seen a red line, running out from each side of the bight of the island, known as the ballast anchorage, to the 15-foot curve and thence along this curve. I can see no better place for depositing the ballast than this, which has been used always for this purpose. No objection has ever been made to this use by the owners of Dog Island. The ballast will be out of the way if placed here.

If not placed here, I recommend that vessels discharge outside in the neighborhood of the line A B, to the southwestward of the entrance to the harbor, in 6 to 8 fathoms of water. Material deposited there will be out of the way and will have no tendency to return to the entrance, because the set of material alongshore is from east to west.

This report has been delayed, as I had hoped to receive the copies of the State law in regard to ballast, for which I wrote while at Apalachicola and again after my return.

Very respectfully, your obedient servant,

F. A. MAHAN,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The following commercial statistics have been furnished by Mr. J. E. Grady, collector of customs, at Apalachicola, Fla.:

Apalachicola is the county seat of Franklin and is situated at the mouth of the Apalachicola River and on Apalachicola Bay. Emptying into Apalachicola River are the Chattahoochee, Flint, and Chipola rivers, and many creeks and streams on which border, in almost inexhaustible quantities, cypress and pine, oak, ash, and cedar, which can be floated to Apalachicola at all times of the year. The only drawback to Apalachicola is the lack of water below, which prevents approach of deeper draft vessels. Apalachicola has along its docks, and for 5 miles above, 22 feet of water, and a channel toward the Gulf to connect with deep water is what is needed to make Apalachicola second to none on the Gulf.

Congress, at last session, recognizing this fact, has ordered a survey to be made of Apalachicola Bay with the view of obtaining an 18-foot channel at low water to the wharves at Apalachicola, and this fact alone is now attracting especially the lumber manufacturers' attention.

I herewith append a statement of the commerce of Apalachicola for year ending June 30, 1896.

	Number.	Tonnage.
Vessels entered as per custom-house books	109	60,000
Vessels cleared as per custom-house books	112	62,311
Number of sail vessels which ply between Apalachicola and ports in the districts which do not have to enter and clear	100	10,000
Number of departures of same	103	10,500
Estimated number of arrivals and departures of river steamers plying from Apalachicola to Columbus, Ga		750
Tonnage of same		89,600
Number of vessels employed in the traffic of Apalachicola		150
Amount of superficial feet of cypress, pine, hewn, and sawed timber shipped ..... feet..		51,321,611
Estimated value of shipments of lumber of all kinds, naval stores, sponge, fish, oysters, and other articles including that in steamboats and other vessels that do not enter and clear		$1,749,350
Imports through the same and other classes of trade		1,862,472
Total value of the commerce of Apalachicola generally		3,611,822

The lumber trade of Apalachicola would have been much larger this year but for the trouble in Cuba, and as soon as that is settled this trade will increase the business of this port on account of our closeness to the island.

There are eight or ten sawmills which ship through Apalachicola which can turn out about 600,000 feet B. M., per day with shingle attachments of 300,000 per day; three oyster-canning factories with a capacity of 60,000 cans per day, also large fish packing and sponge packing establishments. Apalachicola is the natural port or outlet for southwest Georgia and part of Alabama, and these two States are interested in opening up a deep-water channel, as it will be the means of saving many thousands of dollars in freights alone per year.

In the opinion of the writer, if this port is properly cared for and the contemplated 18-foot channel dredged that Apalachicola will return to its former prosperity, when its business amounted to over $14,000,000 per annum prior to 1860.

These figures and statement are made from custom-house records and other information best obtainable, and of course some are estimated.

O 2.

IMPROVEMENT OF APALACHICOLA RIVER, THE CUT-OFF, AND LOWER CHIPOLA RIVER, FLORIDA.

A reconnoissance of this river was made between November 29, 1872, and February 1, 1873. The report of this reconnoissance will be found in the Report of the Chief of Engineers for 1873, pages 698–699.

DESCRIPTION AND CONDITION BEFORE IMPROVEMENT.

The Apalachicola River is formed by the junction of the Chattahoochee and Flint rivers at the extreme southwest corner of the State of Georgia. It runs southwardly through the State of Florida and empties into Apalachicola Bay at the city of Apalachicola. It passes through the low, swampy country overflowed annually by the freshets in the Chattahoochee and Flint. This annual overflow prevents the country adjacent to its banks from being used to any great extent for agricultural purposes. Plenty of timber, however, is to be found on both sides of the river.

The most serious obstacle to navigation found was at Moccasin Slough, 47 miles above the city of Apalachicola. During the civil war the Confederate authorities had placed obstructions here to prevent vessels belonging to the United States ascending the river. These obstructions caught trees, logs, and other floating materials to such an extent as to form an actual dam. The river, however, cut off from its natural course, forced a passage from about a mile and a half above the obstruction to the River Styx. This passage was 3,100 feet in length. Reaching the Styx the water of the Apalachicola River followed it down a distance of three-quarters of a mile until it reached the original river again. It was very difficult to obtain an entrance to the slough by vessels coming down the river, for the reason that the slough bent abruptly, forming an angle of about 180°, and ran in exactly the reverse direction to the current of the river. Moreover, it is only from 80 to 100 feet in width, is very crooked, and has a swift current of more than 5 miles an hour, due to a fall of 2.8 feet. The passage through the slough and the River Styx is 2 or 3 miles shorter than the old channel through the Apalachicola River proper.

The depth of water in the river from the junction of the Chattahoochee and Flint to Apalachicola is at all places more than 6 feet. Its length is about 105 miles, its width about 150 to 200 yards. Every freshet from the Chattahoochee or Flint causes more or less obstruction to navigation by the lodgment of snags and logs in the Apalachicola River.

PROJECT.

The original project submitted in 1873 was to widen and straighten Moccasin Slough and to remove all snags from the river at an estimated cost of $80,333.

The act of August 11, 1888, directed an examination of the "Chipola River, from its mouth to Wewahitchka, and the Cut-off, and Lee Slough, running from the Apalachicola River to the Chipola River." As a result of this examination, made in 1889, the original project was extended so as to include a channel 60 feet wide and 5 feet deep through the Cut-off, Lee Slough, and lower Chipola River.

APPROPRIATIONS.

May 23, 1828	$3,000	July 5, 1884	$1,000
April 23, 1830	2,000	August 5, 1886	1,000
March 2, 1831	8,000	August 11, 1888	2,000
June 23, 1874	10,000	September 19, 1890	2,000
March 3, 1875	10,000	July 13, 1892	5,000
June 18, 1878	8,000	August 17, 1894	5,000
March 3, 1879	5,000	June 3, 1896	5,000
June 14, 1880	2,000		
March 3, 1881	1,500	Total	72,500
August 2, 1882	2,000		

OPERATIONS TO JUNE 30, 1895.

1875.—The steamer *Clara Dunning* was bought and fitted out as a snag boat to work on the Chattahoochee, Flint, and Apalachicola rivers. Work was begun on the Apalachicola River about January 1, 1875. It had to cease at the end of the month on account of high water. It began again in April, 1875, and continued until the end of the year. About 300 snags and logs were pulled out. Overhanging trees were cut down and removed to the northward of and at Moccasin Slough. The slough was partly improved by removing two large rafts, and straightening the channel in and out of the River Styx by cutting away projecting points of land at the junction of this river with the Apalachicola, which made the entrance to the slough exceedingly difficult.

1876.—Snagging was continued during the months of July and August, 1875; 108 snags and sunken logs were pulled out, and over 100 overhanging trees cut and removed, and 1,831 cubic yards of earth were excavated to straighten the channel at the junction of the river with the slough. A large raft of logs lodged near the junction of Moccasin Slough and Styx River, and was removed during June, 1876, leaving the river again in fairly navigable condition.

1877.—A large raft was removed during December, 1876, and January, 1877, from the junction of Moccasin Slough and the Styx. Several large stumps were blown up and taken from the channel at the junction of the Apalachicola River and Moccasin Slough.

1878.—The snag boat was at work at Moccasin Slough from January to the middle of April, 1878. A jetty 130 feet long was constructed on the west side of the upper end of the slough; the point of land on the east side and a small island above the junction were cut away to straighten the channel and force a large volume of water through the slough. Four hundred and eighty-six cubic yards of earth were excavated, more than 270 logs and snags were pulled out of the channel, and many overhanging trees cut and removed.

1879.—Forty-three snags were removed during July, 1878, at various points; 11 logs were removed in November from Moccasin Slough; a large raft of timber was removed from the jetty and another from Styx Island. February, March, and April, 1879, were spent in opening Chipola Cut-off.

In the Annual Report of the Chief of Engineers for 1879 the following is reported:

> The present commerce on this river is insignificant when compared with its former proportions. This diminution is due partly to railroad competition, but the shallow outlet at Apalachicola is the prime cause. With the river bar deepened to 11 feet a fresh impetus would spring up, and the present river commerce would probably be increased $1,000,000.

1880.—A canal 70 feet wide and 5 feet deep was cut across the river between Apalachicola River and the upper end of Moccasin Slough, to avoid the abrupt turn at the junction. Three thousand six hundred and eleven cubic yards of sticky blue clay with a great many logs and stumps were removed in the work. A raft of several hundred logs was removed at Styx Island and another near the mouth of Styx River.

1881.—During this year the canal across the peninsula was completed by the removal of 1,349 cubic yards of clay, and Styx Island was also cut down, 884 cubic yards of material having been removed, making the channel 200 feet wide instead of 80, as it was originally, and 6 feet deep. Six hundred and fifty-two snags and 24 overhanging trees were cut at various points of the river.

Work done on the Chipola River at various times during preceding years had given a channel down to Whites Bluff, a distance of 9 miles, via the Cut-off.

1882.—Ninety-three snags, 72 overhanging trees, 2 rafts of drift, and 3,000 cubic yards of clay were removed from various points of the river.

1883.—The only operations this year were the removal of a large drift raft which had accumulated at Moccasin Slough.

1884.—The operations during this year were confined to widening the canal at Moccasin Slough by the removal of 240 cubic yards of earth, pulling snags, and cutting overhanging timber between the Lower Elbow, 28 miles above Apalachicola, and the junction of the Flint and Chattahoochee rivers. Two hundred and fourteen snags, 108 stumps, and 3 drift piles were removed, and 3,357 overhanging trees were cut.

1885.—Complaints having been made of a few snags in the river in June, it was thought advisable to undertake the work of removing them. The steamer *Clara Dunning*, being worn out in service, had been sold. No reasonable offers for removing snags could be obtained. Authority was granted by the Chief of Engineers June 30, 1885, to charter a small steamer and to tow the United States snag boat belonging to the improvement of Pease Creek to Apalachicola River, to take out the snags which had accumulated during the past year.

1886.—The snag boat mentioned above arrived on August 10, 1885, and began work about a mile and a half above Moccasin Slough, and had worked about a mile up the river when a rise made further effective work impossible for the time. The appropriation being nearly exhausted, it was determined to stop for the season.

1887.—The snag boat *Chattahoochee*, which had been recently constructed for the Chattahoochee River, removed during December, 1886, and January, 1887, 33 logs and snags from the river and 141 overhanging trees from the banks.

1888.—Nothing done.

1889.—The *Chattahoochee* worked during all the month of December, 1888, and removed 2,188 overhanging trees, 112 drift logs and trees cut up on the banks; 304 logs and snags were removed from the channel and 28 overhanging trees were trimmed.

1890.—During November and December, 1889, the *Chattahoochee*, with an average force of 18 men, working thirty-three days, cut 12 projecting stumps level to the banks, felled and cut up 34 overhanging trees, and removed from the channel 270 drift logs and trees, 91 snags, and 3 old piles.

1891.—During April and May of 1891 the *Chattahoochee*, with an average crew of 14 men, removed from the channel and banks of the Apalachicola River and the upper part of Lee Slough, generally known as the Cut-off, 3 old piles, 558 snags and logs, 21 stumps, 2,112 overhanging trees, and 675 bushes.

1892.—During December, 1891, the snag boat removed from the Apalachicola River, the Cut-off, and Lee Slough 520 overhanging trees, 344 projecting drift logs, 14 stumps from the banks, and 313 snags from the channel.

1893.—Fifty-two snags and 708 overhanging trees were removed from the Apalachicola River; 13 snags and logs, 35 overhanging trees, and 52 stumps from the lower Chipola River; 150 snags and logs, 2,832 overhanging trees, 61 stumps, and 403 bushes were removed from the Cut-off; 3,028 snags and logs, 1,218 stumps, 4,452 overhanging trees, and 2,528 bushes from Lee Slough.

The channel through Lee Slough was widened for about a mile in

length. This was accomplished by cutting off the trees, loosening the ground by dynamite, and pulling stumps, allowing the current to wash away the soil. In some cases after the stumps were pulled plowing was done to help the erosion.

1894.—No work was done through lack of funds.

1895.—The snag boat belonging to the river began work in January, 1895, in the Cut-off and Lee Slough. The force was employed to cut the timber from the banks along those places where the channel was to be widened or straightened. As the water rose the snag boat followed the chopping crew to pull the stumps. The earth around the roots of the trees was first shaken by discharging dynamite, and as the roots were pulled the running water washed away the most of the bank inclosing them.

Early in June the snag boat went over the whole length of the Apalachicola River and removed all accessible obstructions, and then returned at low water to work in Lee Slough until the appropriation was exhausted.

Two thousand five hundred and forty-eight logs and snags, 1,707 stumps, and 2,490 bushes were removed, and 2,946 overhanging trees were either felled or trimmed back from the bank.

CONDITION OF IMPROVEMENT JUNE 30, 1895.

The channel was completely opened to navigation except scattered logs and snags, which caused trouble at low water. Overhanging timber and some sharp bends of the banks at the Elbows and Moccasin Slough, which retard boats at all stages of the river, remained to be removed.

The channel through the Cut-off and lower Chipola River was opened to a width of 50 feet in its narrowest portions, but was too crooked to admit of safe navigation at low water.

OPERATIONS DURING THE YEAR ENDING JUNE 30, 1896.

No channel work was done during the past fiscal year, as the appropriation had been exhausted during the preceding year.

RECOMMENDATIONS AND ESTIMATES.

The country bordering on the Apalachicola River depends almost entirely upon the river for its transportation. The completion of the improvement is essential to the development of the region. If the amount appropriated by the river and harbor act of 1896 is made available there will still be required $6,000 for the completion of the improvement. Of this amount, $2,000 will complete the clearing of the Cut-off and lower Chipola River, according to the approved project of 1890; $2,000 will finish the improvement of Moccasin Slough and the Elbows, and $2,000 will be required to maintain the improvement. No special working plant is required on this river, as the snag boats of the Flint and Chattahoochee rivers can be used here when not in use elsewhere.

It is recommended, therefore, that $6,000 be asked for the completion of the work on this river and for maintenance during the fiscal year ending June 30, 1898.

Money statement.

July 1, 1895, balance unexpended	$1,308.19
Amount appropriated by act of June 3, 1896	5,000.00
	6,308.19
June 30, 1896, amount expended during fiscal year	1,031.68
July 1, 1896, balance unexpended	5,276.51

Amount that can be profitably expended in fiscal year ending June 30, 1898	$6,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	.

COMMERCIAL STATISTICS.

The commercial statistics of the main channel of the Apalachicola River are so combined with those of the Flint River that a separation is impossible, and reference is made to that river for figures.

O 3.

IMPROVEMENT OF FLINT RIVER, GEORGIA.

DESCRIPTION, AND CONDITION BEFORE IMPROVEMENT.

The Flint River rises about 20 miles southwest of Atlanta, in Georgia, runs nearly due south, bending a little toward the eastward, and finally joins the Chattahoochee River at the extreme southwest corner of the State of Georgia. The junction of these two streams forms the Apalachicola River. A survey was authorized by the river and harbor act of June 10, 1872. The survey was begun at Albany, Ga., in November, 1872, and finished in May, 1873. Obstructions to navigation on the Flint River were rock shoals formed chiefly of loose rocks of various sizes, becoming more frequent in going up the river. The character of the bed, while increasing the cost of the work, will tend to make it more permanent.

PROJECT.

The project for this work proposes a channel 100 feet wide, with a depth of 3 feet at extreme low water, from Chattahoochee, Fla., to Newton, Ga., a distance of $71\frac{3}{4}$ miles, at an estimated cost of $118,105; and from Newton to Albany, Ga., a distance of $33\frac{1}{4}$ miles, at an estimated cost of $66,757, making a total of $184,862 for a distance of 105 miles.

The river and harbor act of June 18, 1878, called for an examination of the Flint River between Albany and Montezuma, Ga. This examination showed that the removal of logs and snags and overhanging trees throughout the entire distance, estimated at 77 miles, would give a navigable channel for light-draft steamers throughout the greater part of the year. This work was estimated to cost $15,100.

APPROPRIATIONS.

For Chattahoochee and Flint rivers:		March 3, 1881	$15,000
June 25, 1874	$25,000	August 2, 1882	25,000
March 3, 1875	25,000	July 5, 1884	20,000
August 14, 1876	20,000	August 5, 1886	20,000
		August 11, 1888	20,000
Total	*70,000	September 19, 1890	20,000
		July 13, 1892	15,000
June 18, 1878	10,000	August 17, 1894	8,000
March 3, 1879	7,000	June 3, 1896	8,000
June 14, 1880	20,000	Total	188,000

*Of this amount $18,000 was expended on Flint River.

OPERATIONS TO JUNE 30, 1895.

1874.—No work was done.

1875.—No work was done.

1876.—All snags, logs, and overhanging trees interfering with navigation, from the mouth of the river to Bainbridge, Ga., were removed by the snag boat during the year. Two light-draft flatboats were built to accommodate working parties and fitted out with necessary blasting and hoisting apparatus.

1877.—Nothing done.

1878.—Work was begun early in November, 1877, when a blasting boat and party were transferred from the Chattahoochee. Beginning at the wharf at Bainbridge and working down to Lamberts Island, 763 cubic yards of rock and 168 logs were removed. A channel 4 feet deep and 60 feet wide was obtained over that distance.

1879.—Improvements were completed at Lamberts Island, Broad Axe, and Bryants Rocks. Work was suspended December 1 and resumed May 15. One thousand one hundred and fifty-four cubic yards of rock and 80 snags were removed. The average amount of powder per cubic yard of rock removed was 1.5 pounds.

1880.—During the fiscal year the channel of the river was completed to the projected depth and width, viz, 4 feet deep and 100 feet wide, by the removal of rock between Red Bluff and Bainbridge, completing the improvement from the mouth of the river to 10 miles above the latter point. Work was begun at Winding Shoals, 22 miles above Bainbridge. The result of this work has been to give a channel 4 feet in depth by 100 feet wide where formerly the average depth was but 1 foot and the average width but 40 feet. Fifty miles of river was cleared, so as to give a good navigable channel during the entire year up to this time.

1881.—Work was begun in March, 1881, on the section of the river between Albany and Montezuma, near Drayton, Ga. The work done in this part of the river consisted in 697 snags removed and 549 overhanging trees cut. Below Albany work was done at Winding Shoals, Crawfords Point, and to 9 miles below the latter. Three hundred and ninety running feet of jetty was built at the first-named point; 56 snags and 2,393 cubic yards of rock were removed altogether.

1882.—Work done below Albany consisted in the removal of 2,627 cubic yards of rock and 59 snags and the construction of 350 running feet of stone dikes. Above Albany 3,365 snags were removed and 36 overhanging trees cut down.

1883.—Work was done above Albany for a length of 12 miles, in which distance 3,853 snags were removed and 250 overhanging trees cut down. Below Albany work was done over a length of $1\frac{1}{4}$ miles; 2,439 cubic yards of rock and 101 snags were removed. The condition of the river on the 30th day of June, 1883, was such that low-water steamers drawing 3 feet could run from the mouth of Swift Creek to within $4\frac{1}{2}$ miles of Montezuma.

1884.—The remaining $4\frac{1}{2}$ miles to reach Montezuma was cleared, and $44\frac{3}{4}$ miles of the river was worked over; 2,332 snags were removed and 115 overhanging trees were cut. Below Albany 10 miles of the river was worked over; 66 snags were removed, 58 overhanging trees cut, and 2,954 cubic yards of rock excavated.

1885.—A small hand-power snag boat was kept at work on the river between Montezuma and Swift Creek, effecting the removal of 12,961 snags and overhanging trees. A number of drilling scows on the reefs about 20 miles below Albany took out 2,202 cubic yards of rock over a

distance of 18½ miles. This party removed all the snags and overhanging trees in this section of the river.

1886.—The small hand-power snag boat was kept at work between Montezuma and Warwick, taking out 814 snags and overhanging trees. The drilling scows on the reefs about 19 miles below Albany removed 5,477 cubic yards of rock and 440 snags and overhanging trees.

1887.—Nothing was done during the year 1887.

1888.—Five hundred and eighty-five snags and overhanging trees and 5,325 cubic yards of rock were removed from the river by an average force of 32 men in one hundred and thirty working days. About half the rock required blasting before it could be handled. The rock was in ledges and bowlders of compact limestone, honeycombed by solvents and containing nodules of flint.

1889.—Nothing was done above Albany. Below Albany an average force of 19 men working one hundred and sixty days with the drilling barge removed 236 snags and overhanging trees, 1,815 cubic yards of solid rock, and 817 cubic yards of bowlders and loose rock.

The snag boat *Chattahoochee*, with 15 men working two hundred and forty-six days, removed 1,340 overhanging trees, 121 drift logs, and 213 logs and snags from the channel.

1890.—Above Albany.—Thirteen men working sixty-five days removed 901 snags and logs and overhanging trees, an old ferryboat, and the boiler of a sunken steamer. These obstructions were scattered along an estimated distance of 56 miles.

Below Albany.—Nineteen men working ninety-six days removed 77 snags and 1,412 cubic yards of rock from the channel.

1891.—Above Albany.—The snag boat *Flint* removed 236 snags and logs and 12 cubic yards of loose rock from the channel, 24 stumps and logs and 234 overhanging trees from the banks.

Below Albany.—The drilling barge removed 415 cubic yards of ledge and loose rock from the shoals at Albany. The snag boat *Chattahoochee* removed during the month of June, 1891, 85 snags and logs and 3 cubic yards of bowlders from the channel, 70 stumps and logs and 1,493 leaning trees from the banks.

1892.—Above Albany.—During the first four months of the fiscal year the snag boat removed 1,652 overhanging trees from the banks and 1,785 logs and snags from mid-channel in a distance of 50 miles.

Below Albany.—Five hundred and eight overhanging trees were removed from the banks, and 444 snags and 3,203 cubic yards of rock from mid-channel. The rock was deposited wherever needed to form substantial wing dams, and a total length of 380 running feet of these was built.

1893.—Above Albany.—No channel work was done.

Below Albany.—Nothing was done between the mouth of the river and Bainbridge, except the removal of a few snags. Between Bainbridge and Albany 5 miles of the river at Lucky Island and Ferguson Shoals received attention; 255 overhanging trees were cut from the banks, 89 snags and 2,440 cubic yards of rock were removed from the stream, and 177 running feet of training dams was built.

1894.—Above Albany.—No work was done.

Below Albany.—The drilling barge finished the work at Ferguson Shoals. It then went 9½ miles down the river to Odons Shoals, which it cleared out; thence it went down 3 miles farther to Newton Shoals, where work was continued until the appropriation was exhausted. The work done included the removal of 500 overhanging trees, 202 stumps, 79 snags and logs, and 1,008 cubic yards of rock.

1895.—Above Albany.—Nothing was done.

Below Albany.—Work was done on the rock shoals near Newton, 42 miles above Bainbridge. Thirty-five overhanging trees and 39 snags and logs were removed, 413 cubic yards of rock was removed and 247 yards was placed in the dikes.

CONDITION OF IMPROVEMENT JUNE 30, 1895.

Above Albany.—As no commerce was attempted during the year on this part of the river, no examination of its condition was made; it may be assumed, however, that it was bad.

Below Albany.—There was a completed channel, navigable at all seasons of the year, between Albany and Kennedy shoals, a distance of 35¼ miles. Navigation was impossible at very low water on account of rocks between Kennedy Shoals and Bainbridge, a distance of about 40 miles. Below Bainbridge the river was navigable at all seasons, and this portion of the river was well used by steamers plying the Chattahoochee and Apalachicola rivers.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1896.

Work was progressing at Kennedy Shoals at the opening of the year. When work was finished at this point the drilling barge was dropped down to Sisters Islands, a mile below, and worked until the end of October, when the appropriation was exhausted, and the boats were taken up to winter quarters near Baconton, Ga.

The shoals at Sisters Islands, and generally all along this part of the river, consisted of siliceous masses ranging in size from bowlders of about 2 cubic yards down to gravel of 2 or 3 inches. As the rock material is removed from the channel, it is deposited in spur dikes along the banks to maintain the normal flow of the stream.

The amount of work accomplished is as follows: Six stumps and 50 overhanging trees removed from the banks, 75 snags and logs removed from the channel, 1,667 cubic yards of rock removed, of which 1,033 cubic yards was deposited in spur dikes. The cost of the work, including getting the boats to winter quarters, was $3,301.50.

REMARKS.

In carrying on the work with present appliances, the bowlders are first broken by blasting. When the water is not too deep the fragments are removed by men wading in the stream, who hand them to their comrades upon the dumping flat. When the water is too cold or too deep for wading grappling tongs are used to load the flat. The removal of rock in this way costs about $2 per cubic yard. The price varies, however, with the condition of the stream during the working season. Men wading when the water is not over 4 feet deep will pick up by hand three times as much rock as they can grapple with tongs in 6 feet of water. A small dredging machine would handle this material more readily than it is possible to handle with the present manual appliances, and would effect a saving of 75 per cent of the cost if it removed the obstructions as readily as it is believed it would—that is to say, an outlay of $6,000 for a dredge out of an appropriation of $8,000 would remove as much rock as the present method, and leave a good machine on hand for further work.

The drilling barge and dumping flat, built in 1889, are badly decayed. They will certainly not stand another year unless very extensive repairs are made. If this were done the boats might last a year or two longer. It would be more economical, however, to build entire new hulls.

RECOMMENDATIONS AND ESTIMATES.

There is no question as to the advisability of continuing the improvement of this river from the mouth to Bainbridge. There is a stretch of bad river between Newton and Bainbridge which can be navigated with care during moderate stages, but it is impracticable at low water. As the low-water season is that of the removal of the cotton crop, the best trade of the year is lost to navigation. There is no doubt that if the river were in good condition at low water there would be a considerable increase in the commercial movement.

It is recommended, therefore, that the work be continued hereafter as it has gone on in the past, except that a dredge and dump scows be built for the use of the Flint and Chattahoochee rivers, at a cost of $15,000, one-half of the cost being borne by each river.

The estimated cost of what is required for judicious expenditure during the coming year on this river is:

Five months of the snag boat *Flint*	$5,000
Eight months of the drilling barge	8,000
New hulls for the drilling barge and flatboat	6,000
Dredging machine and two barges (one-half)	7,500
Total	26,500

Money statement.

July 1, 1895, balance unexpended		$5,813.10
Amount appropriated by act of June 3, 1896		8,000.00
		13,813.10
June 30, 1896, amount expended during fiscal year		4,874.75
July 1, 1896, balance unexpended		8,938.35
July 1, 1896, outstanding liabilities		65.94
July 1, 1896, balance available		8,872.41
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		26,500.00

COMMERCIAL STATISTICS.

A small steamer, *Little Vixen*, 20 tons register, 12 inches light draft and 24 inches loaded, made some trips between Bainbridge and Chevertown, but no statistics could be obtained.

A new steamer, the *J. P. Williams*, 75 tons register, 18 inches light draft and 30 inches loaded, has just been completed, to make two trips weekly between Bainbridge and Newton, Ga.

Between Bainbridge and the mouth of the river the stream is well used by the steamers plying the Chattahoochee and Apalachicola rivers, and for the commerce of this section of the river reference is made to the following table:

Stern-wheel steamboats.	Registered tonnage.	Draft.		Round trips.	Passengers carried.
		Light.	Loaded.		
		Inches.	*Ft. In.*		
Fannie Fearn	179.32	24	5 0	20	2,784
Bay City	87.45	20	4 0	32	2,967
Apalachee	161.90	28	5 0	52	5,840
Flint	135.51	18	5 0		
Naiac	173.44	22	3 6	30	3,250
Queen City	150.03	24	4 6	22	3,200
J. F. C. Griggs	175.17	20	4 0	32	2,753

Amount of lumber rafted down the river is not known, but it is covered in report for Apalachicola Bay.

Freight carried.

Articles.	Quantity.	Tons.
Cotton.....bales..	9,967	2,515
Cotton seed.....sacks..	5,549	323
Fertilizers.....do....	30,526	2,871
Hides and skins.....bundles..	52	4
Live stock.....head..	252	87
Staves.....pieces..	300	1
Lumber.....feet B. M..	163,000	345
Provisions.....packages..	132,773	4,383
Grain.....sacks..	20,694	1,544
Miscellaneous freight.....packages..	48,000	6,303
Bricks.....number..	576,000	856
Naval stores.....barrels..	32,089	7,602
Shingles.....number..	4,248,000	883
Total.....	.....	27,717

Estimated value of above freight, $1,944,816.

O 4.

IMPROVEMENT OF CHATTAHOOCHEE RIVER, GEORGIA AND ALABAMA.

GENERAL IMPROVEMENT.

Description and condition before improvement.—The Chattahoochee River rises in the extreme northern part of Georgia, whence it flows southwestwardly until it strikes the boundary line between Georgia and Alabama, at West Point, Ga.; thence it flows nearly due south, forming the boundary line between the States of Georgia and Alabama and, farther on in its course, between Georgia and Florida, until it joins the Flint, forming the Apalachicola River. The river does not become navigable until it reaches Columbus, Ga., an estimated distance of 224 miles above its junction with the Flint. Between these two points there are more or less of obstructions to navigation, but the records of this office are so incomplete that it is impossible to give any detailed information on the subject between Columbus and Eufaula.

The report of the survey of the Chattahoochee River, shown on pages 584–585, Report of the Chief of Engineers for 1872, contains an estimate for the improvement of the Chattahoochee and Apalachicola rivers from Columbus, Ga., to Apalachicola, Fla., at a cost of $464,000. No project is made in that report.

In the Report of the Chief of Engineers for 1873, page 700, three estimates were presented, as follows:

1. For removal of snags, logs, and loose rocks, insuring a 4-foot channel between Eufaula, Ala., and the junction with the Flint at low water, $63,333.

2. For straightening and widening this 4-foot channel to 100 feet, $81,914.

3. For deepening this channel to 6 feet at low water, 100 feet wide, $982,945.

The engineer officer then in charge of the improvement of the river stated in his annual report:

> I consider the improvements included in estimates Nos. 1 and 2 sufficient for the requirements of navigation. * * *

This would make the estimated cost of the improvement of this part of the river $145,247.

No estimate has been found of the cost of the portion between Columbus, Ga., and Eufaula, Ala.

PROJECT.

The project then adopted, and which is still in force, provides for a low-water channel 4 feet deep and 100 feet wide from Columbus, Ga., to Chattahoochee, Fla., an estimated distance of 224 miles, by the removal of snags and logs from the channel and overhanging trees from the banks; cutting a channel through the rock shoals, and deepening sand bars by works of contraction and shore protection.

APPROPRIATIONS.

February 24, 1835	$2,000	March 3, 1881	$20,000
		August 2, 1882	25,000
Chattahoochee and Flint rivers:		July 5, 1884	35,000
June 23, 1874	25,000	August 5, 1886	20,000
March 3, 1875	25,000	August 11, 1888	20,000
August 14, 1876	20,000	September 19, 1890	20,000
		July 13, 1892	†25,000
Total	*70,000	August 17, 1894	†30,000
		June 3, 1896	†25,000
June 18, 1878	18,000		
March 3, 1879	15,000	Total	273,000
June 4, 1880	20,000		

OPERATIONS TO JUNE 30, 1895.

1874.—Nothing done.

1875.—The steamer *Bandy Moore* was chartered in the latter part of August to work on the river. Operations were begun in September and continued until the latter part of December. The steamer *Clara Dunning*, which had been bought for use on the Chattahoochee and Flint and Apalachicola rivers, was fitted out as a snag boat and was put to work October 31, 1874. Work was done mainly on Wolfax (Woolfolks) Bar, where a jetty 275 feet long was built to concentrate the water into one channel. The wreck of the sunken steamboat was removed from the head of the bar, and over 500 cubic yards of sand, gravel, and rock was excavated from the channel. Seventy-three snags and sunken logs were pulled out, and a large number of overhanging trees cut down and removed above and below the bar. The works were successful, and good water was obtained.

1876.—High water in the Chattahoochee River interfered with the work until the latter part of August, 1875, the work having been suspended in December, 1874. A few landslides interfered seriously with navigation. As soon as the stage of the water permitted, snags and overhanging trees carried into the channel by these landslides were removed and the improvement of Wolfox (Wolfax—Woolfolks) Bar resumed. It was found that the jetty constructed in 1875 had done much to deepen the channel. It had also begun to abrade the Georgia shore, and had formed a new bar below the old one. Three hundred and eighty feet of shore protection was built on the Georgia shore to prevent further washing, and a jetty 200 feet long was built below this to

*Of the joint appropriations $52,000 was expended on the Chattahoochee River.

† Of each of these appropriations $5,000 was to be expended between West Point and Franklin.

prevent the formation of a new shoal. The jetty above the bar on the Alabama side of the river was built high enough to prevent the river from washing around it. Before the work was done a sudden rise in the river compelled suspension until May, 1876.

1877.—Work was resumed at Wolfax (Woolfolks) Bar. It was found necessary to protect the head of the jetty by rock riprap, and to extend the shore protection on the Georgia side to the south end of the bar, a distance of 560 feet. The snag boat was employed in removing snags and cutting overhanging trees during the month of July. Work was suspended in July, and the snag boat was sent to the Apalachicola River. The boat was ordered to Columbus in February, 1877, for necessary repairs. A new hull had to be built. All the machinery, etc., had been transferred to it by the end of the year. One hundred and eleven cubic yards of rock was removed in August from Little Uchee Shoals, giving a channel 60 feet wide and 4 feet deep at low water. Work was then begun at Slick Bluff and continued there until the middle of November, when a channel 55 feet wide and 3 feet deep had been obtained and several isolated rock reefs above and below this shoal removed. Five hundred and eighty-two cubic yards of rock was excavated. A rise in the latter part of November prevented further blasting operations, and after the removal of 21 sunken logs from Hardridges Shoal work was suspended for the season. Work was begun again in April, 1877, and 138 cubic yards of rock had been removed from the Middle Rock at the close of the year.

1878.—Work was resumed at Woolfolks Bar in July. The shore protection on the Georgia side was lengthened 200 feet and the jetty on the Alabama side about 570 feet. Two short wing dams 90 by 40 feet were built in order to protect this channel still further. These works were finished in October, giving a channel with not less than 4 feet at low water over this bar. The bars at Abercrombie, Shell Creek, Chimney Bluff, and Snake shoals were greatly improved by the removal of sunken logs and snags and overhanging trees. Work was continued on Uchee, Slick Bluff, and Hardridges shoals. Over 600 cubic yards of rock was removed from those bars, besides a large number of snags and sunken logs. A channel 60 feet wide and 4 feet deep at low water was obtained over those shoals, which were very dangerous to navigation.

1879.—The river being low and badly obstructed by snags, their removal was first undertaken during the summer. Seven hundred and ninety-eight snags were removed and a large number of overhanging trees cut down. At Coachmans Bar not less than 128 logs, which had well nigh closed navigation, were removed. The jetty at Shell Creek, which had been damaged by high water, was repaired. Work was resumed at Woolfolks in May. A break of 100 feet in length of the shore protection on the Georgia side was repaired, and the improvement of Upatoir (Upatoie) Bar begun. This was to be removed by wing dams putting out from each bank. Eleven of these, each about 40 feet long, were built out from the Georgia shore, and three, of 100 feet each, from the Alabama shore. A blasting barge, with a derrick and quarters for workmen, and a dumping scow and a magazine boat were built.

1880.—Work was done at Jennies Island, Abercrombies Bar, Woolfolks Bar, Upatoie Bar, Uchee Shoals, and Culpepper Island. Five hundred and eighty cubic yards of rock was removed at Uchee Shoals; 2,693 running feet of jetties built at Abercrombies, Woolfolks, Upatoie, and Culpepper. A barge was sunk at Jennies Island to obstruct a false channel.

The improvements made up to this time gave the following results

Names of places.	Distance.	Original depth.	Present depth.	Original width.	Present width.	Remarks.
BELOW COLUMBUS, GA.	*Miles.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
Abercrombies Bar	8	1	3.5	350	150	Contracted with wing dams.
Woolfolks Bar	10	1.5	4	500	150	Do.
Upatoie Bar	11	2	4	300	150	Do.
Shell Creek Bar	24	3	3	350	350	Shore protection.
Little Uchee Shoals	17	2	4	50	60	Reef blasted; too narrow.
BELOW EUFAULA, ALA.						
Reef below Little Uchee	17.5	1.5	4	50	60	Do.
Slick Bluff Reef	18	0	4	39	55	Part of dry reef blasted off.
Middle Rocks	18.5	1.5	4	30	80	
Big Uchee Shoals	19	1.5	4	35	65	
Culpepper Island Bar	32	2	4	400	150	
Hardridges Shoal	27	2	4	35	80	

1881.—Work was confined to the improvement at Culpepper Island, where 1,769 cubic yards of rock was removed.

1882.—Six hundred and forty snags and overhanging trees removed; 1,689 running feet of jetties built, 77 running feet of jetties repaired, 2 bars plowed, 2,614 cubic yards of rock removed, 960 cords of brush fascines made and put in place.

1883.—Two hundred and ninety-two snags and overhanging trees removed, 2,060 running feet of jetties built, 1,968 cubic yards of rock removed. Rock was blasted and removed at Codys Rock, Bettons Upper Rock, and Bettons Lower Rock. The channel at Uchee Shoals was widened from 60 to 80 feet. The portion of the river near Columbus and between it and Bull Creek was improved by contracting its width from 300 to 160 feet, thereby deepening the channel from 2 to 4 feet.

1884.—Uchee Shoals was widened from 53 to 65 feet and deepened from 2 to 4 feet. The head of the shoal was widened from 29 to 65 feet and deepened 2 feet. The channel at Slick Bluff was widened from 55 to 70 feet and deepened 1½ feet, thus giving 4 feet above low water. The work done during the year consisted in removing 634 snags, 2,531 cubic yards of rock, building 2,377 running feet of jetties, and repairing 668 running feet.

1885.—The snag boat was at work until September 17, when it was run ashore to keep it from sinking, having rotted out its second hull on this work. One thousand one hundred snags and logs and trees were removed from the channel as well as the wrecks of two steamers and one flatboat. At Uchee Shoals, 3,764 cubic yards of rock was taken out in a distance of 300 feet.

1886.—A new snag boat was built at a cost of $12,000. All the serviceable engines and machinery and other parts of the old boat were introduced into the new. Forty-six logs, snags, and trees were taken out of the channel. Four thousand four hundred and seventy-three cubic yards of rock and 11 cubic yards of clay were taken out at Uchee Shoals, over a length of 5,000 feet.

1887.—The new steam snag boat was in use for five months, removing 1,733 logs and trees and the wreck of one steamer. At Uchee Shoals the drilling barges removed in four months 3,007 cubic yards of material and 2 logs, extending the prescribed channel a distance of 1,740 feet.

1888.—Work at Uchee Shoals went on from June to December, 1887. Three thousand eight hundred and eighteen cubic yards of material

and 5 logs were removed. The snag boat took out between the middle of September, 1887, and February, 1888, 1,349 trees and snags, and part of the wreck of a steamer. Repairs were made to the jetties 7 miles below Columbus.

1889.—With an average force of 15 men working ninety-one days on the snag boat and an average force working seventy-three days on the drilling barge, 2,225 logs, snags, and overhanging trees were removed from the channel at various points on the river, and 753 cubic yards of marl and rock removed from Uchee Shoals.

1890.—The snag boat worked over the river from Chattahoochee, Fla., to Columbus, Ga., a length of 223 miles, removing during three months, with an average force of 16 men, 904 logs, snags, and overhanging trees. The drilling barge, with a force of 24 men working two months, removed 576 cubic yards of rock, 10 cubic yards of marl, cut 12 cords of brush, planted 98 willows, made 330 running feet of rock-dump jetties, and laid 228 cubic yards of brush and rock-dump bank protection.

1891.—During the autumn of 1890, work was begun on the marl shoals 75 miles below Columbus. A crew of 20 men working six weeks removed 248 cubic yards of marl and 144 cubic yards of gravel, making a channel 120 feet wide and 4 feet deep; at Fitzsimmon Bend, 27 miles below Columbus, in two weeks the same crew removed 25 trees from the banks, 10 snags, and 166 cubic yards of marl from the channel and widened the 4-foot channel from 75 to 90 feet.

1892.—The snag boat felled and cut up 924 overhanging trees and trimmed 33 others; 81 drift logs were cut up on the bank, and 366 snags removed from the channel. Work was begun on the improvement of Mound Bar by the construction of pile and brush bank protection, training walls and jetties, and the removal of gravel and clay from the channel. A total of 1,110 running feet of jetty and bank protection was constructed, this work involving the driving and bracing of 992 piles, the cutting and depositing of 480 cords of brush, and transplanting 1,082 willows and other suitable trees. A channel 600 feet long and 30 feet wide was cleared by plow and road scrapers pulled by steam capstans, thus removing 1,098 cubic yards of gravel and 403 cubic yards of clay.

1893.—Drift was removed from the channel by the snag boat and then it and the drilling barge resumed work at Mound Bar, 7 miles below Columbus, Ga., where the improvement was continued by plowing out the bar along the axis of high water and confining the low water to this channel by a series of longitudinal and transverse dikes, and by protecting the foot of the caving structures. During the clearing of the river between August and October, 1892, 409 logs and snags and 1,013 overhanging trees were removed from the river. At Mound Bar 126 old piles and 805 cubic yards of gravel were taken out; 1,700 running feet of dikes and 400 square yards of bank-protection mats were put in. At Woolfolk (Wolfox—Wolfax) Bar the hull of the old steamer *W. D. Ellis* was sunk to form a jetty 175 feet long preliminary to future prosecution of the improvement at this point.

1894.—The snag boat worked over the full length of the river. With the pile-driving barge it began work again on the improvement of Woolfolk Bar. An area 100 yards long by 156 wide was plowed twice through the sand and gravel of the bar, and two dikes were built out from the Georgia bank to close partly the low-water run and to deflect the stream to the proposed channel.

1895.—Work was continued on Woolfolk Bar by plowing out the

channel, building the necessary training dikes, and protection of shores. This required the removal of 27 overhanging trees, 405 snags, logs, and old piles, 6 cubic yards of old rock ballast, and 11,282 cubic yards of gravel and sand; 230 running feet of old dikes was repaired, and 627 running feet of new dikes and 484 square yards of bank protection were built.

Nine hundred and ten running feet of dikes and 60 square yards of bank protection were repaired at Mound Bar. At Hospital Reach 186 running feet of dikes and 56 square yards of bank protection were repaired.

CONDITION OF IMPROVEMENT JUNE 30, 1895.

The low-water channel below Eufaula, Ala., was nearly free from obstructions, and boats drawing 3½ feet had little difficulty in navigating the river.

The channel between Eufaula and Columbus, Ga., was obstructed by sand and gravel bars, particularly at St. Francis Bend, 5 miles above Eufaula, and at Hospital Reach, Woolfolk Bar, and Old Head of Uchee, all within 20 miles of Columbus. Steamers were delayed from one to forty-eight hours in passing each of these obstructions. Improvements had been made at the three last-mentioned places, and as long as the works remained in good order there was no delay in passing the bars. The improvements made at Mound, Abercrombies, Upatoie, and Shell Creek bars had all been successful. The dikes and bank protection built of piles and brush were decaying rapidly and were in need of repair to prevent their early destruction.

The channel cut through the marl reefs at Uchee, Culpepper, and Kowikee Shoals, and through the rock reefs at Hardridges and Widow Browns shoals was clear and in good order.

Logs and snags, the result of winter freshets, were scattered throughout the full extent of the river and endangered navigation at low water.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1896.

The river and harbor bill of 1894 carried an allotment of $10,000 for rebuilding the hull of the snag boat *Chattahoochee*. As this vessel was entirely unserviceable, the snag boat *Flint*, belonging to the Flint River improvement, was started at Chattahoochee, Fla., July 1, 1895, and cleared the river of all accessible snags up to Columbus, Ga., a distance of about 224 miles. After finishing that work the *Flint* joined the pile-driver boat and the crews of both resumed work at Woolfolk Bar. This work ceased on August 10, 1895, the appropriation available being exhausted. The plant was then taken to Burdock Landing and laid up.

In the work thus outlined, 29 overhanging trees were removed between Chattahoochee and Columbus; at Woolfolk Bar an area of 4,165 square yards was plowed, and 695 cubic yards of gravel was removed by the scrapers; 230 running feet of longitudinal dikes and 30 running feet of shore protection were built, requiring the driving of 66 piles, the cutting and placing of 41 cords of brush, and the depositing of 156 sacks of gravel to weight down the brush.

A breach occurred in one of the dikes in October, 1895. This threatened the ruin of the whole system of improvement at Woolfolk Bar, so far as it had been carried out. The breach was caused by the current cutting under the end of the dike which abutted against the hull of an old boat (hull No. 1 of *Clara Dunning*, about 1875–1878, no record exists

of time), utilized in a former attempt at improvement. As the case was urgent, immediate action was taken. A few materials were secured to supplement some odds and ends on hand, laborers were employed, and the repairs were made satisfactorily. Piles were driven at intervals of 5 feet, and 2-inch planks battened together were put down on the upstream side and fastened to the piles by wire ties and spikes. Sacks of gravel were placed along both sides of the planks, and loose gravel poured in to fill the interstices, until the foot of the dike was secured against further washing.

To head off the current from the repaired dike, a light longitudinal dike of piles and plank 3 feet deep was built for a distance of 200 feet downstream from the next cross dike above.

Other dikes of the improvement were examined, and where signs of washing or other weakness appeared, the holes were stopped by plank, sacks of gravel, or both.

In making these repairs 71 piles were driven, 3,900 feet B. M. lumber was used for planks, braces, etc., 100 pounds spikes and bolts, and 300 pounds No. 5 wire ties were used. Thirty old piles and logs, 6½ cubic yards of rock, 1,461 sacks of gravel, and 65 cubic yards of loose gravel were used as filling and ballast.

In this connection I wish to give due credit to the assistant engineer, Mr. Thomas Robinson, in local charge of the improvement of this river, for his good judgment and prompt action in making these repairs.

REBUILDING HULL OF SNAG BOAT CHATTAHOOCHEE.

In April, lumber, iron, oakum, and paints were secured, and on the 20th of the month work was begun on the Georgia bank of the Chattahoochee River, opposite Burdocks Landing, Ala. By June 30, all of the skeleton timbers, viz, 105 flows, 210 ribs, 210 cocked hats, and 4 rake blocks were cut to shape, and the bow and stern transom timbers were fitted together. Out of these the stern was set up, and 79 frames running forward were bolted to the middle and side keelsons, the side clamps, and the deck stringers. The work as thus outlined constitutes about one-half of the framework of the hull.

The cost thus far is:

Order for lumber, 63,342 feet B. M.	$1,813.28
Order for iron	334.01
Order for paints	133.85
Wages, mechanics, laborers, etc	872.00
Repairs to wheel shaft, etc	105.00
Provisions, oil, etc	152.56
Superintendence and incidentals	312.00
Total	3,722.70

CONDITION OF IMPROVEMENT JUNE 30, 1896.

As the amount of money available for this river during the past year was very small, and admitted only of a hurried clearing of the river of snags and logs and a small amount of work at Woolfolk Bar, the condition of the river remains practically the same as it was June 30, 1895.

REMARKS.

Experience shows that the bars of this river are composed in most cases of too coarse or too tenacious materials to be controlled readily and economically by dams built of pile and brush; moreover, the water is already as shallow as safe navigation will admit below most of the

bars. If by reason of heavy scour gravel is forced out of the channel made over the bar, it lodges a little farther down and forms the nucleus of another bar, and so on. For these reasons a small dredging machine is needed to supplement the scouring action of the current, and the use of such a machine would dispense with entirely, in many cases, brush dams, and render a piece of work permanent which, with brush and ballast, can at best be only temporary.

The hulls of the pile-driver barge and of one of the flatboats are rotten. It is doubtful whether any patching would carry them through until June 30, 1897.

RECOMMENDATIONS AND ESTIMATES.

The commerce of the Chattahoochee River warrants a good channel. Four boats run weekly between Columbus, Ga., and Apalachicola, Fla., going up the Flint River to Bainbridge regularly, and occasionally as far as Chevertown, Ga., on the way.

It is recommended that all the old works of improvement, etc., be put in repair, and that the necessary improvements be pushed as rapidly as possible.

In order to accomplish this the plant must be put in order by rebuilding the hulls of the pile driver and flatboat mentioned, and the acquisition of a small dredging machine. It would be economy to build a dredge for the joint use of the Flint and Chattahoochee rivers. The cost of such a dredge and two dump scows would be about $15,000.

The estimated cost of what is contemplated for the Chattahoochee River is as follows:

Dredge and scows (half cost)	$7,500
Removal of annual accumulation of snags, logs, etc	5,000
Rebuilding hulls of barge and pile driver	5,000
Completion of improvement at Woolfolk Bar	4,000
Repairs to works at Hospital, Upatoie, Shell Creek	25,000
Excavating and controlling the channel in St. Francis Bend	30,000
Excavation of rock, etc., at Rock Island, King Rock, etc	21,000
Total	97,500

This amount can be expended judiciously and advantageously during the fiscal year ending June 30, 1898.

Money statement.

July 1, 1895, balance unexpended	$13,302.22
Amount appropriated by act of June 3, 1896	20,000.00
	33,302.22
June 30, 1896, amount expended during fiscal year	3,854.96
July 1, 1896, balance unexpended	29,447.26
July 1, 1896, outstanding liabilities	3,366.30
July 1, 1896, balance available	26,080.96
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	97,500.00

COMMERCIAL STATISTICS.

The commercial statistics for the Chattahoochee River are so combined with those of the Flint River that a separation is impossible, and reference is made to that river for figures.

IMPROVEMENT OF CHATTAHOOCHEE RIVER, GEORGIA AND ALABAMA, BETWEEN WEST POINT AND FRANKLIN.

DESCRIPTION.

This section of the Chattahoochee River is 38 miles long. It is divided into a series of pools, varying from half a mile to 5 or 6 miles in length, by rock shoals and rapids, some of which have a fall as great as 8 feet in a mile. The width of the pools is from 300 to 500 feet, and their depth not less than 4 feet. The width of the stream at the shoals is from 800 to 1,000 feet, and the depth of the water is only a few inches.

PROJECT OF IMPROVEMENT.

The river and harbor act of September 19, 1890, provided for a preliminary examination of this section of the Chattahoochee. As a result of this examination, made in November, 1890, it was recommended that a survey be made for the purpose of founding a project of improvement and estimate of cost. The division engineer and the Chief of Engineers did not agree to this, so no survey was ever made.

The river and harbor act of July 13, 1892, allotted $5,000 from the general appropriation for the Chattahoochee River to be spent on this section.

In response to a call for a project for the expenditure of this sum, the following was submitted on July 26, 1892:

> To remove the lesser rock shoals, sand and gravel bars by excavation and works of contraction; to remove overhanging trees from the banks, and snags, logs, and other obstructions from the channel, and to overcome the more serious obstructions by the construction of locks and dams to give a minimum depth of 3 feet at low water in the channel between West Point and Franklin, a distance of 38 miles.

Recommendation was made "that a party be organized for working on the shoals between West Point and Bentley Mill, and continue working until the shoals are put in as good condition as practicable or until the funds are exhausted."

These recommendations were approved August 5, 1892.

APPROPRIATIONS.

An allotment of $5,000 was made from the river and harbor act of July 13, 1892, a second of the same amount from the act of August 17, 1894, and a third of the same amount from the act of June 3, 1896, in all $15,000, have been given to this part of the river.

CONDITION OF IMPROVEMENT JUNE 30, 1895.

A low-water channel 50 feet wide and 3 feet deep had been obtained through Roberts and Flat Rock shoals, and work had been begun at Haynes Island Shoals.

WORK DONE DURING FISCAL YEAR ENDING JUNE 30, 1896.

Work was resumed at Haynes Island Shoals on July 16, 1895, and suspended on November 9, the work on these shoals being finished.

The amount of rock excavation was 395 cubic yards, costing $5.95 + per cubic yard.

This cost was made up thus:

Addition to plant	$52.64
Labor	1,328.04
Engineering and superintendence	241.67
Subsistence	374.47
Material	274.83
Miscellaneous	79.28
Total	2,350.93

Adding to this $293.94 spent during the year 1895 there is obtained as the total cost of improving this shoal, $2,644.87.

There was spent during the year the sum of $291.53 for cutting overhanging trees, removing snags, etc.

RECOMMENDATIONS.

As much has been done on this section of the Chattahoochee as can be accomplished without undertaking an extended system of slack-water navigation. So far as can be learned there is no commerce on this part of the river, hence the cost of such expensive work would not be justified; it is recommended, therefore, that further work on this part of the river be abandoned.

As the last allotment made is insufficient to do any work on an extended scale, it is further recommended that nothing more be done for the present.

Money statement.

July 1, 1895, balance unexpended	$3,561.62
Amount appropriated by act of June 3, 1896	5,000.00
	8,561.62
June 30, 1896, amount expended during fiscal year	3,142.46
July 1, 1896, balance unexpended	5,419.16

O 5.

IMPROVEMENT OF CHOCTAWHATCHEE RIVER, FLORIDA AND ALABAMA.

DESCRIPTION.

The part of this river considered for improvement is that from the mouth to Newton, Ala., an estimated length of 162 miles. It may be divided into four sections: (1) From the mouth to Caryville, where the Pensacola and Atlantic Railroad crosses the river, 100 miles; (2) from Caryville to Geneva, 25 miles; (3) from Geneva to Hollis Bridge, 30 miles; (4) from Hollis Bridge to Newton, 7 miles.

The section below Caryville runs through a sparsely settled country, where the business is almost exclusively the cutting and rafting of timber.

The second section is the most used, nearly all of the commerce of the stream being here.

The third section is used as far as Pate Landing (25 miles above Geneva) when freight is offered at favorable stages of water.

The fourth section can not be used during low stages of the river.

The second and third sections were of very difficult navigation, as the channel was greatly obstructed by snags and logs; during times of low water sand bars offered an additional hindrance to the commerce of the stream. A series of nine shoals, formed by strata of very compact blue clay, makes low-water navigation impossible between Hollis Bridge and Newton. When the project for the improvement of the Choctawhatchee River was adopted the town of Newton was dependent on the river for communication with the outside world. The Alabama Midland Railway has been completed since then from Montgomery, Ala., to Bainbridge, Ga.; this road passes through Newton, consequently the urgent necessity for improving the fourth section of the river exists no longer.

PROJECT.

The project for the improvement of the Choctawhatchee River proposes to obtain a low-water navigable channel from the mouth of the river to Newton, Ala., by the removal of logs and snags from the channel and overhanging trees from the banks, by cutting through the rock shoals, and deepening sand bars through the medium of contraction works and protection for the shores.

This project has since been amended to require a draw, approved by the Secretary of War, to be placed in Hollis Bridge before any money may be spent above this bridge.

The estimated cost of the project of 1872 was $34,332.

This estimate revised in 1880 increased the cost to $112,832.

APPROPRIATIONS.

March 3, 1833	$5,000	August 2, 1882	$18,000
June 15, 1844, for Choctawhatchee and Holmes rivers	10,000	July 5, 1884	15,000
		August 5, 1886	15,000
		August 11, 1888	10,000
June 25, 1874	5,000	September 19, 1890	12,500
March 3, 1875	5,000	July 13, 1892	12,500
August 4, 1876	5,000	August 17, 1894	6,000
March 3, 1879	5,000	June 3, 1896	5,000
June 14, 1880	7,000		
March 3, 1881	10,000	Total since 1874	131,000

The cost of the work on this river up to June 30, 1896, has been $127,835.52.

OPERATIONS TO JUNE 30, 1895.

No appropriation was made for this river during the thirty years from June, 1844, to June, 1874. The results of work done to about 1844–45 had disappeared, in all probability, long before 1874; the period from 1874 on will be the one considered.

1874.—Nothing done.

1875.—A length of 48 miles from the mouth of the river was cleared. Over 300 large logs and snags were pulled out and more than 1,000 overhanging trees cut down and removed.

1876.—Work was suspended in September, 1875, owing to lack of funds. Work was confined to the removal of snags, stumps, and overhanging trees. The result of the work done up to this time was a channel 3 feet deep at low water from the mouth up to 15 miles below Geneva.

1877.—Work was begun in May, 1877. A light-draft steamer was chartered to work in connection with the snag boat, so as to forward operations as much as possible. One hundred and eighteen snags and stumps were taken out and more than 300 overhanging trees were cut and removed, to the end of the year.

1878.—Work was suspended in August, 1877, on account of lack of funds. Six hundred and thirty snags and 1,200 overhanging trees had been removed, and the shoal at Miller's Field had been deepened by the removal of drift and gravel.

1879.—There having been no appropriation, no work was done.

1880.—Twenty miles of the river was cleared of snags and overhanging trees. Three months was spent in removing snags and other obstructions to navigation which had accumulated in another part of the river which had already been cleared, as the result of one of the hardest freshets known on this river, occurring in October, 1879.

A cut-off 60 feet wide and 7 feet deep was opened by the removal of snags, stumps, and overhanging trees to enable boats to avoid the obstructions caused by the wreck of the steamer *Eighth of January*, the removal of which was prevented by a too high stage of the water. Buzzard Bar, 15 miles below Geneva, was also cleared out, giving a good navigable channel with over 3 feet to 6 feet of water where formerly the depth was 14 inches to 2 feet.

The greater part of the wreck of the steamer *Boston*, including nearly all the machinery, was removed and placed on the bank. The part not removed was sufficiently below the water surface not to interfere with navigation.

Five hundred and forty-six snags, stumps and logs, 5,247 overhanging and submerged trees, and 22 cubic yards of sand were removed from the bed of the river, in addition to what was mentioned previously. The river had at that time a comparatively safe channel, with a depth of 4 feet at all stages of the water, to a point 120 miles above the mouth of the river.

1881.—Four months' time was consumed in removing the obstructions to navigation which had accumulated in the part of the river already cleared. The entire wreck of the steamer *Edward*, near Bear Pen Bluff, and one-half of that of the *Eighth of January*, about 7 miles below Cerrogordo, were removed.

A cut-off was opened through a narrow strip of land about 3 miles below Halfmoon Bluff; 1,377 snags, 151 stumps, 2,445 sunken trees, 10,283 overhanging trees, a large lot of willows, drift and brush, and 252 cubic yards of sand were taken out.

1882.—A log boat 76 feet long, 17½ feet beam, and 3½ feet depth of hold was built in August, 1881. The necessary outfit and tools were purchased and operations were begun at the mouth of the river by the removal of the delta known as Cypress Top, which is the only mouth used by boats, it having 4½ feet of water at medium tide. Work was begun there August 17, and carried to the head of Cowford Cut-off, a distance of 40 miles. This work was completed during the latter part of January, 1882, when the log boat was carried up to Geneva, Ala. Work on the river from Geneva upward to Newton, Ala., was taken up during the early part of February and continued to the latter part of May, 1882, when work was suspended on account of failing of appropriation.

Between August 17, 1881, and May, 1882, there were removed altogether from the river 872 snags, 1,068 stumps, 483 roots, 360 logs, 1,311 sunken trees, 6,075 overhanging trees, 6 large drifts of logs, trees, brush, etc., and 12 cubic yards of sand, and 330 running feet of bank was protected from washing.

At Harvesins (Harvestons) Whirl, Carters Drive, Buzzard Bar, Parrotts Creek, and near Pittmans Ferry, where 2 feet could scarcely be carried at low water, 5 feet could be carried at the end of 1882. The channels through the Ninety-nine Islands, through the Boston and Cowford Cut-off, had also been improved so that boats drawing 5 feet of water could pass through them safely.

As a result of the improvement of navigation there were put on the river, even during the early stage of the work in 1875, 1 steamboat, 2 sloops, and 1 barge, which, with the 2 barges and 1 sloop already running, were kept busy in supplying the increasing demand for freights. Several steamers from Pensacola and Freeport made occasional successful trips to Geneva, and business kept steadily increasing.

The width of the river has not been changed materially or increased

by the improvements (the average width being 350 feet), except at Harvesins (Harvestons) Whirl, Carters Drive, and Buzzard Bar, where, owing to the removal of drift, saw logs, sunken trees, and timber which had lodged in the sand and narrowed the river down to scarcely 60 feet. It has widened since to nearly 400 feet, with 5 feet depth of water.

1883.—Work was begun both above and below Geneva in October, 1882. In consequence of a heavy storm and high freshet in September much work had to be done while going up the river in the part improved during the preceding year. During the working season 24 miles of river was wholly improved and 29 miles was partly improved and required to be worked over again.

The total amount of work during the fiscal year was as follows: Thirty-four miles wholly improved; 161 partly improved, requiring to be worked over again; 758 snags, 550 stumps, 441 roots, 486 logs, 1,913 sunken trees, and 10,926 overhanging trees were removed, 4,940 running yards of bank protected, and 70 cubic yards of sand taken out; 6 sloughs and cut-offs closed, and 1 large drift pile taken out.

1884.—During the year ending June 30, 1884, the following work was done: Thirty-five miles of river was wholly improved by the removal of 16,265 snags, stumps, and logs, and 13,554 overhanging and submerged trees; 990 running feet of bank was protected. In addition to all this there was a great deal of other work done of which no quantities are given, like removal of roots, willows, piles, drift, etc.

It is stated in the Annual Report for 1884, page 1182, that—

Wherever sunken trees, logs, and snags have been removed the channel has deepened 2 and 3 feet, and even more at different places.

Wherever sand bars had existed at and behind points and the sunken trees, brush, drift, etc., that held the sand were removed so as to allow the current to follow its natural course, these sand bars have been washed away into deep holes without shoaling any other portion of the river, and where before the improvement scarcely 4 or 5 inches of water existed 3 or 4 feet are now found.

1885.—The only record found in the Annual Report for this year is that the snag boat was kept at work between Geneva and Halfmoon Bluff removing logs and snags from the channel and overhanging trees from the banks between these points.

1886.—There were removed from the river during this year 8,787 snags, logs, and overhanging trees, over a distance of 32 miles.

1887.—Work was begun by the snag boat *Choctawhatchee* in September, and the river was cleared of the principal obstructions between Caryville, Fla., and Geneva, Ala. In December the snag boat began work between Geneva and Newton, together with a small boat upon which a separate party was employed. These two boats were continuously employed between Newton and Pate Landing, and a third party organized during a favorable stage of water in the river was employed on the same ground clearing the river of obstructions to within 5 miles of the latter point. A similar party was organized and was employed successfully during low water during the month of June on the rock shoals below Geneva, removing from that point some 3,000 loose rocks, stones, and bowlders. In all, 384 overhanging trees were cut and removed and 15,500 logs and snags and 414 cubic yards of rock were removed from the channel; the distance worked over by the several parties was 49¾ miles.

1888.—The snag boat and a small flatboat provided with a hand capstan were employed between Geneva and Newton from July 1 to November 24, 1887. The work was interrupted from time to time by high water, and was discontinued on November 24 in consequence of the appropriation being exhausted. Work was done over about 25

miles of the river; 5,772 logs and snags were removed from the channel and 231 overhanging trees from the banks.

1889.—The snag boat was employed from July 21 to November 18, 1888, when work was suspended on account of high water. The following obstructions were removed: Five hundred and twenty-three large logs, 799 small logs, 761 large snags, 1,100 small snags from the channel; 695 overhanging trees were felled and cut up on the banks. The work was resumed on May 11, 1889, between Geneva and Newton, but no statement is given of what was done at the end of the fiscal year.

A contract was made with M. A. Sweeney & Bro., of Jeffersonville, Ind., for building a new snag boat with a steam capstan, but no propelling power, at a cost of $4,800. The vessel was to have been delivered on May 1, but on account of unavoidable delays the time of delivery was extended to July 10, 1889.

1890.—Work was carried on from July 1 to September 30, 1889, in the upper part of the river in the neighborhood of Pate Landing, but no record of the amount of work is given.

1891.—Work was begun in May, 1891, and was carried on upstream from Caryville, Fla. No record of the quantity of work done is given.

1892.—Work was carried on from July 1, 1891, to December 10, 1891, when it was suspended on account of high water. It was resumed May 24, 1892, and continued until the end of the year. The following work was done: Two thousand one hundred and forty-two snags were removed from the channel, 386 overhanging trees from the banks, 456 logs cut up on the bank, and 4 stumps leveled off. Many of the snags were very large and had to be broken by dynamite before they could be handled. Alterations were made to the snag boat, fitting it with a stern-wheel and driving machinery.

1893.—Shore protection and contraction works were put in at Buzzard Bar, Gumfield Shoals, and Busby Shoals, with the result of giving greatly increased depths of water. At Buzzard Bar the minimum depth of 1½ feet was increased to 3½, and the maximum of 7 feet was increased to 9; at Gumfield Shoals the minimum depth of 1 foot was increased to 3.2 feet, while the maximum of 5 feet was increased to 6½; at Busby Shoals the improvement was a transverse dike running about halfway across the river and then carried downstream parallel with the current a distance of about 400 feet; depths were increased all through anywhere from seven-tenths of a foot to 2.2 feet.

In addition to this the amount of work performed was as follows: Nine hundred and ninety-three snags removed from the channel, 231 overhanging trees from the bank, and 25 stumps cut off level with the bank.

1894.—Work was done at Harvestons Whirl and at the Cut-off. At the former place several wattled dikes were built about halfway across the river from the left bank; opposite them a shore protection was built on the right bank, and a little above a deep cavity in the right bank was closed by means of a transverse dike running about halfway across the river with a longitudinal arm extending downstream. The result of the work was to regularize the channel and to increase its depth greatly. The work at the Cut-off consisted in closing the entrance to Old River, which makes out from the left bank of the Cut-off. This was closed by a double thickness of wattled dikes, taking the shape of the shore of the Cut-off. A sand bar which made out from the opposite bank nearly halfway across the river was cut away from a maximum depth of 4 feet up to nothing close in by the right shore.

In addition to these works the following was also done: One thousand one hundred and sixty-seven snags, 249 logs, and 17 cubic yards of rock were removed from the channel; 55 overhanging trees were felled and cut up, 100 logs cut up on the bank, and 210 trees were pulled back.

1895.—The snag boat was thoroughly overhauled during the winter of 1894–95. The water having reached a working stage, work was begun on April 29, 1895. The following had been done up to the end of the fiscal year: One hundred and ninety snags, 213 logs removed from the channel, 288 overhanging trees felled and cut up, 396 logs cut up on the bank, and 185 trees pulled back.

CONDITION OF IMPROVEMENT JUNE 30, 1895.

The work done under the approved project had secured a good channel, 3.5 feet deep at low water, from Caryville, Fla., to Geneva, Ala. Its width varied from 60 to 120 feet, the narrow portions being found only at the bars, which had been deepened by contraction works.

As operations had to be suspended during the season of 1894 by the appropriation having become exhausted, in the first place, and by the lateness of the date of passage that year of the river and harbor act, the obstructions carried into the stream by the rises of 1893–94 and 1894–95 had made some reaches of the river dangerous, especially for boats moving at night.

The contraction works had already secured a sufficient depth over the bars which they were intended to remove, and no shoaling had been noticed. These shoals have been improved or removed in this way: Busby Shoals, Buzzard Bar, Gumfield, Harvestons Whirl, and the Cut-off. Bank protection was put in at the Cut-off just below Harvestons Whirl.

The snag boat had been at work wherever its services were needed.

Works of contraction have been put in at Busby Shoals, Buzzard Bar, Gumfield Shoals, Harvestons Whirl, and the Cut-off. The type of structure adopted at these places consists of rows of piles wattled with heavy poles. The construction is cheap and quickly made. It has proved satisfactory.

The amount of work done at each place is as follows:

Busby Shoals.—A transverse dike 168 feet long connects with a longitudinal dike 462 feet long, the whole costing $924.21.

Buzzard Bar.—Four transverse dikes having a total length of 644 feet, costing in all $944.75.

Gumfield Shoals.—Two transverse dikes having a total length of 380 feet, costing $557.46.

Harvestons Whirl.—Four transverse dikes having a total length of 647 feet, a longitudinal dike 480 feet long, shore protection 580 feet long, costing in all $1,997.19.

Cut-off.—Shore protection 115 feet long, longitudinal dam to close the mouth of old river 285 feet long, costing in all $468.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1896.

No works of contraction were carried on.

The snag boat *Choctawhatchee* removed obstructions from the channel of the river between Caryville, Fla., and Geneva, Ala. The boat made two trips over the river; the most dangerous obstructions were removed on the first trip; the second trip saw the removal of practically all

snags and sunken logs from the channel. The following obstructions were removed:

Overhanging trees felled and cut up	39
Overhanging trees felled and pulled back	28
Stumps leveled on bank	61
Logs removed from drift piles	241
Stumps removed from drift piles	306
Snags removed from river	741
Logs removed from river	965
Total number of pieces handled	2,381

at a total cost of $2,854.66, or $1.199 each.

RECOMMENDATIONS AND ESTIMATES.

The report of Mr. Turtle, assistant engineer in local charge of this river, has the following:

It is recommended that the snag boat be kept at work each season removing such obstructions as are brought into the channel during high water, and that the pile driver be employed for about two low-water seasons continuing contraction works at a few of the shoalest bars, and protecting caving banks by driving longitudinal rows of piles.

The contraction works and bank protection employed have secured very satisfactory results, and their continuance is recommended.

The necessary work of maintenance is growing less each year, and in the future the snag boat can assist greatly in placing contraction works.

To obtain the most economical and permanent results, this work should be prosecuted for a few seasons without any delay. After this is done maintenance alone will be required.

I agree with these views and recommendations. The sum of $20,000 can be expended advantageously during the fiscal year ending June 30, 1898, in carrying them out.

Money statement.

July 1, 1895, balance unexpended	$4,102.98
Amount appropriated by act of June 3, 1896	5,000.00
	9,102.98
June 30, 1896, amount expended during fiscal year	3,938.50
July 1, 1896, balance unexpended	5,164.48
July 1, 1896, outstanding liabilities	61.00
July 1, 1896, balance available	5,103.48
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	20,000.00

COMMERCIAL STATISTICS.

Capt. T. M. Day, A. F. Tatom, and G. L. Bledsoe, of Geneva, Ala., report the following commercial statistics for the fiscal year ending June 30, 1896:

Stern-wheel steamboats.	Registered tonnage.	Draft.		Passengers carried.	Round trips between Geneva and Caryville, Fla.
		Light.	Loaded.		
		Inches.	*Inches.*		
Annett	102.50	18	36	165	96
Mary Alice	39.37	18	30	240	110
Joe Davis	95.44	18	33	1,000	104

Freight carried.

Articles.	Quantity.	Tons.
Cotton.....bales..	5,565	1,399
Cotton seed.....sacks..	300	15
Fertilizers.....do	37,912	3,791
Hides.....packages..	81	19
Lumber.....feet B. M..	110,000	190
Provisions.....packages..	13,989	1,256
Grain.....sacks..	14,587	1,146
Miscellaneous freight.....packages..	82,081	8,136
Total.....	.....	15,952

Estimated value not reported.

O 6.

IMPROVEMENT OF PENSACOLA HARBOR, FLORIDA.

DESCRIPTION, AND CONDITION BEFORE IMPROVEMENTS WERE BEGUN.

Pensacola Harbor, the finest harbor on the Gulf of Mexico, is at the extreme western end of the State of Florida.

Pensacola Bay is a large sheet of water of irregular shape, separated from the Gulf of Mexico by Santa Rosa Island, which is part of the littoral cordon of the Gulf.

Between Santa Rosa Island and the mainland lies Santa Rosa Sound, a strip of water 37.5 miles long and varying in width from an eighth of a mile to 2 miles.

A long tongue of land making in from the eastward separates Santa Rosa Sound from the greater part of Pensacola Bay. North of this tongue of land Pensacola Bay divides into two arms, which have their axes nearly north and south. The west arm is called Escambia Bay, into the northern end of which empties Escambia River. The eastern arm is in two parts—East Bay, with its extension northward, called Blackwater Bay.

Pensacola Bay is 24 miles long from the extreme eastern end of East Bay to the entrance from the Gulf. Its total water surface, including Escambia, East, and Blackwater bays and the western part of Santa Rosa Sound, is about 150 square miles.

The entrance to Pensacola Bay is at the extreme western end of Santa Rosa Island. The bay lies wholly to the east of the entrance. The passage through the gorge of the entrance is very deep, reaching at one point as much as 52.5 feet. Inside of the entrance, and for a distance of 9 or 10 miles, vessels drawing 30 feet of water can move easily and safely.

It is not easy to gain the entrance to the bay. Access thereto is denied by a bar, on which there is rarely, even at the deepest point, more than 21 feet of water at mean low tide. This bar is roughly elliptical in shape. Starting from the shore to the west of the entrance, at a point 1,900 feet beyond the front beacon of the McRee range, the axis of the bar swings around gradually to a point on the shore line rather more than 4,500 feet to the east of Fort Pickens. This curve may be divided into two unequal parts, one about two-thirds of its development from the west, the other about one-third from the east, the point of division being nearly midway between the 18-foot curves, and in a depth

of 21 feet, more or less, according to circumstances. The western two-thirds of the bar is called the Caucus Shoal; the eastern third is called the East Bank. Inside of this bar a shoal makes out from the western end of Santa Rosa Island; it is called the Middle Ground; it has its axis nearly north and south.

The passageway between the Caucus Shoal and the East Bank is called the outer bar; that between the Caucus and the Middle Ground is called the inner bar. A cut has been dredged several times to a depth of 24 to 26 feet across the inner bar; as its axis made always a wide angle with the direction of the currents, especially those of the ebb, the cut has closed up again soon after each opening.

The passageways across the outer and inner bars have narrowed gradually; the nearest points of the various curves of depth have had the following distances between them at the dates mentioned:

Inner bar.

Distance between—	1822.	1856.	1890.	1895.
	Yards.	*Yards.*	*Yards.*	*Yards.*
12-foot curves	2,050	1,525	2,050	2,000
18-foot curves	1,400	1,350	225	367
21-foot curves	1,125	1,050	*667	*133

*These two measurements are taken along the sailing line; all the others are taken across it.

Outer bar.

Distance between—	1822.	1856.	1890.
	Yards.	*Yards.*	*Yards.*
18-foot curves	1,925	1,100	850
21-foot curves	950	500	350
24-foot curves	875	1,075	1,000

In this table the distance between the 24-foot curves is measured in the direction of the sailing lines; the distances between the other curves are taken across the sailing lines to the nearest points of the curves.

Up to 1856, at least, vessels drawing not more than 18 or 20 feet of water could beat into the bay; to-day even steamers have to be very carefully handled to avoid going ashore.

PROJECTS OF IMPROVEMENT.

Project of 1877.—This project included only the removal of four wrecks, these being a ship of 1,200 tons, wrecked on the Middle Ground in 1869; a bark of 900 tons, wrecked alongside of the preceding in March, 1872; a steamer of 375 tons, wrecked about half a mile south of the light-house in 1864; a pilot boat of 34 tons, sunk in 4½ fathoms of water, 1 mile north-northeast of the outer bar buoy, on May 31, 1875.

Project of 1878.—This project, as definitely presented, was: First, to remove the above wrecks by contract; second, to make an examination or survey to determine the most advantageous expenditure of any remaining balance of the appropriation, or for further recommendation for improvement.

Project of 1881.—This project was presented by the Board of Engineers of February 12, 1881. It provided for dredging a channel 300 feet

wide and 24 feet deep at mean low water across the inner bar, and for protecting the shore line near Fort McRee from further abrasion by the construction of jetties and works of shore protection, with the view of preventing further injurious changes in the tidal currents and also of retaining the position for defensive purposes. The water on the inner bar was then only 19.5 feet deep. This project will be found in full in the Report of the Chief of Engineers for 1881, page 117.

Project of 1891.—This project, prepared by a special Board of Engineers, was presented July 16, 1891. It provides, briefly, for the building of two jetties, one from the west end of Santa Rosa Island, the other from the west side of the entrance to the bay, the jetties to have shore arms normal to the water line of the shore and to be of such length as to bring their outer ends 4,500 feet apart when finished; the jetties from the ends of the shore arms are to follow as nearly as possible the line of the ebb currents, and to converge toward each other so that the distance between them at their outer ends should be 3,500 feet. Dredging to hasten the opening of the new channel is also a part of the scheme. The full report of this Board may be found in the Report of the Chief of Engineers for 1891, page 1723.

First amendment to the project of 1891.—A special Board of Engineers appointed "to reconsider the project for the improvement of the harbor of Pensacola, Fla.," presented its report on August 20, 1895. This Board made no change in the project of 1891. It recommended "that the engineer officer in charge be directed to take the necessary steps to secure immediately the use of one of the powerful hydraulic dredges now owned by the United States, one of which is believed to be available, and to open a channel 26 feet deep at mean low water, and as wide as practicable, on the line of the deepest water across Caucus Shoals, approximately on the line of the axis of the jetty channel recommended by the Board of 1891, and that he be authorized to use for this purpose as much of the funds now available as may be necessary." This report may be found in the Report of the Chief of Engineers for 1895, page 1657.

Second amendment to the project of 1891.—This amendment was submitted by the same Board that recommended the first amendment, one officer having been added to the Board. It is as follows:

1. The Board recommends that all funds now available be expended in continuing the work of dredging across Caucus Shoal.

2. If funds sufficient for the construction of a suitable dredge, and for its operation for a period of at least two years, be made available by the next river and harbor act, the Board recommends that such a dredge be built and a channel opened across Caucus Shoal at least 300 feet wide, having a least mean low-water depth of 30 feet, with such side slopes as the material will assume.

Until a channel be opened by dredging across Caucus Shoal, as herein proposed, the Board recommends that the question of constructing jetties for its economical maintenance be not further considered.

The existing conditions at the western end of Santa Rosa Island and near Fort McRee should, however, be maintained by the construction, if necessary, of suitable shore protection, which may be utilized as bases for jetties should their construction become imperative.

APPROPRIATIONS.

June 18, 1878	$20,000	August 11, 1888	$35,000
March 3, 1879	10,000	September 19, 1890	25,000
June 14, 1880	40,000	July 13, 1892	75,000
March 3, 1881	20,000	August 17, 1894	100,000
August 2, 1882	50,000	June 3, 1896	200,000
July 5, 1884	55,000		
August 5, 1886	20,000	Total	650,000

OPERATIONS TO JUNE 30, 1895.

A contract was made in 1878 for the removal of the wrecks mentioned in the projects of 1877 and 1878 at a cost of $8,600, the work to be begun November, 1878, and to be completed by May 1, 1879. Bad weather caused great delays, and the contract was not declared finished until December 15, 1879.

1882.—Dredging.—A contract was made July 28, 1881, to dredge the channel across the inner bar at a cost of 29 cents per cubic yard. No work having been done, the contract was annulled and new proposals were asked. The award was made June 26, 1882, at 40 cents per cubic yard.

Proposals were received to build the jetties called for in the project of 1881. The bids received were considered excessive and were rejected. Instructions were given to do the work by hired labor and by purchase of materials in open market. Work was begun in October, 1881. A jetty just abreast of Fort McRee was started. The shore end, formed of crib work filled with brush mattresses and rock ballast, extended 60 feet from mean low-water line; piling for the jetty was completed 250 feet from same line. Satisfactory results were obtained; the beach line near the jetty advanced 25 to 50 feet; a shoal formed along the shore, so that at a distance of 100 feet from the mean low-water line the depth was reduced from 9 to 3 feet between January and June.

1883.—Dredging.—No work was done by contractor at 40 cents per cubic yard. New bids were received December 1, 1882. The contract was awarded to Seth N. Kimball, the lowest bidder, at 79.7 cents per cubic yard. Work was begun on April 30, 1883; 8,406 cubic yards was removed up to June 30, at a cost of $6,699.58.

The jetty, which will be called hereafter the south jetty, was finished. The shore line advanced about 120 feet, and a marked change took place to the northward of the jetty.

1884.—Dredging.—Work done during the year amounted to 24,966.25 cubic yards removed at a cost of $20,567.85. This gave a channel 22.5 feet deep at mean low water, 80 feet wide, and 1,900 feet long. The depth at high water was 24 feet.

The shore line advanced about 130 feet during the year.

1885.—Dredging.—Dredging was continued under the Kimball contract until its termination on August 9, 1884; the quantity of material removed from the channel was 16,387.75 cubic yards at a cost of $13,060.96. The result was a widening of the channel to 120 feet and deepening it to 24 feet at mean low water. A new contract for dredging was made during the year at 74.74 cents; it was annulled on account of no work having been done. A dredge was hired at a cost of $333.33 per day, and dredging was begun by day labor on May 25, 1885. Up to June 30 there had been removed 36,982.5 cubic yards in 302 hours of working time, giving an average of 122.46 cubic yards per hour at 34.5 cents per cubic yard. The total cost of this work was $12,666.51.

No work was done on the jetties.

1886.—Dredging.—Dredging was done during the fiscal year to the amount of 55,354.71 cubic yards at a cost of 29.9 cents per cubic yard, or a total cost of $16,551.06. The least depth reported on June 30, 1886, was 23 feet.

No apparent change took place in the shore line at the jetties. More or less damage was done to them by storms, especially those of June 20 and 29, 1886.

1887.—No dredging was done.

A pile bulkhead was built to protect the abutment of the north jetty during winter storms. A new wharf was built to receive stone for the construction of more permanent jetties, the old ones having become almost entirely destroyed through the piles and mattresses being eaten away by the teredo, and through the action of the storms in scattering stone which had been used to weight down the brush mattresses.

1888.—No dredging was done during the year. The least mean low-water depth reported at the end of the year was 22 feet. There was delivered 1,716.58 tons of stone, of which 1,187 tons was put in the north jetty. The north jetty was originally 220 feet long. It was gradually destroyed until not more than 10 per cent of it was left. Two hundred running feet was rebuilt with stone placed as nearly upright as possible. The stone was laid from the shore. Small stones from 40 to 250 pounds in weight were used to form the core; large stones from 1 to 4 tons in weight were used for the side slopes and coping. Mattresses, which were found to be unnecessary and which were quickly destroyed, were finally abandoned as foundations. The shore line at the jetties remained unchanged. It receded from 30 to 70 feet for a distance of several hundred feet north of the jetties, then for a distance of several hundred feet farther it made out; it receded from 40 to 70 feet for about 500 feet on either side of the front beacon of the McRee range.

1889.—No dredging was done during this year.

There was remaining of the south jetty not more than 25 per cent, the remainder having been destroyed. The stone blocks on the outer 100 feet of the north jetty were much shaken down by the storm of August 19, 1888; no further injury was produced by subsequent storms. The construction of concrete blocks for use in the two jetties was carried on during a great part of the year.

1890.—No dredging was done.

Actual work on the repairs of the north jetty was begun in July, 1889, and completed on June 25, 1890. Work was begun at once on the south jetty, which was finished on April 16, 1890. Bad weather caused the work on the north jetty to be very expensive.

A resurvey of the entrance to the harbor was begun in April, 1890, and finished during the same year.

1891.—No dredging was done during this year.

A Board of Engineers was appointed January 17, 1891, to consider and report upon the improvement of Pensacola Harbor. The Board reported on July 16, 1891; the project which they laid down is to be found under the heading of projects in this report.

1892.—The channel across the inner bar had become so bad that it was necessary to do something for the relief of the harbor. The hydraulic dredge *Bayley* was hired for this purpose at a cost of $400 a day. Work began on June 28, 1891, and ended on July 16 of the same year. It resulted in the removal of 14,150 cubic yards at a cost of $7,839.23, or 55.4 cents per cubic yard.

The jetties remained in good condition. No change reported in the shore line.

1893.—A contract was made with Rittenhouse Moore to dredge the channel across the inner bar at the price of 63 cents per cubic yard; this contract was approved October 29, 1892. Work was to have been begun on January 1, 1893. The dredge which was to have done this work was lost on its way from Mobile to Pensacola. The contractor had to have a new dredge built; this vessel was tried first on May 24, 1893, but it was found to be so incomplete that it was necessary to haul it off for repairs, and work was not resumed until June 7, 1893,

the dredge being still incomplete. The amount of material removed up to the 30th of June was 27,852.37 cubic yards, at a cost of $17,546.99. The time spent in pumping was 94 hours 48 minutes, which gives an average of 3.37 cubic yards of sand removed per minute. The time lost in turning and dumping was 43 hours 3 minutes. The time lost from other causes was 206 hours and 1 minute.

No change in conditions of the jetties and shore line in their neighborhood.

1894.—Moore's contract was finished on August 15, 1893, the funds available for carrying on the work being exhausted. The amount of material removed was 92,505.17 cubic yards, at a cost of $58,278.26. The time spent in pumping was 357 hours 20 minutes. The amount of material removed per minute was 4.31 cubic yards. The time lost in turning and dumping was 231 hours 44 minutes. Time lost from other causes, 137 hours 52 minutes.

1895.—The engineer in charge of the harbor recommended that the funds provided by the river and harbor act of 1894 be expended in procuring a dredge and in carrying out the portion of the project of the Board of Engineers of 1891 relating to dredging. This recommendation was disapproved and instructions were given to prepare specifications for beginning the construction of the jetties. Specifications were prepared to this end, and bids were opened on June 29, 1895.

Amount and cost of dredging before July 1, 1895.

Year.	Cubic yards.	Total cost.	Year.	Cubic yards.	Total cost.
1883*	8,406.00	$6,699.58	1892‡	14,151.00	$7,839.23
1884*	24,966.25	20,567.85	1893§	27,852.37	17,546.99
1885*	16,387.75	13,060.96	1894§	92,505.17	58,278.26
1885†	36,982.50	12,666.51			
1886†	55,354.71	16,551.06	Total	276,605.75	153,210.44

* Contract with S. M. Kimball at 79.7 cents per cubic yard.
† Dredge *Bayley* hired at $333.33 per day.
‡ Dredge *Bayley* hired at $400 per day.
§ Contract with Rittenhouse Moore at 63 cents per cubic yard.

CONDITION OF IMPROVEMENT JUNE 30, 1895.

Jetties.—The jetties built near Fort McRee were in good order, notwithstanding their having been exposed to two of the severest storms ever known on this coast.

Channels.—The depth of water on the inner bar was found to be but 20.45 feet at low water June 26, 1895. The width of the channel was reduced to 100 feet.

OPERATIONS DURING THE YEAR ENDING JUNE 30, 1896.

The bids opened June 29, 1895, for beginning the construction of the west jetty proposed by the project of 1891 were sent to the Chief of Engineers on July 5, 1895, with the request that action on them be deferred until a special report on this harbor, then in preparation, could be received. This report was forwarded on July 27, 1895. It was referred to a special Board of Engineers July 31, 1895. The Board reported August 20, 1895. The essential feature of the report is contained in the first amendment to the project of 1891.

In accordance with the Board's recommendation, which was approved by the Secretary of War August 26, 1895, application was made to the

Chief of Engineers for the use of the United States dredging steamer *Gedney*, belonging to New York Harbor. Col. G. L. Gillespie, Corps of Engineers, under whose charge the dredge was, could spare the vessel from his works and was willing to let it come to Pensacola for temporary use. Under these conditions the Chief of Engineers approved of its being lent to the Pensacola work.

The *Gedney* started from New York October 7, 1895, and arrived at the Pensacola Navy-Yard October 20. Three days were spent overhauling ship. Work was begun on the morning of October 23, 1895.

The minimum depth on the axis of the channel which it was proposed to dredge was only 14.4 feet. This depth was found very close to the 18-foot curve on the outside slope of the bar, which dropped quickly into deep water. The distance from the depth of 14.4 to the point where the 23-foot curve is intersected by the axis of the new channel is only 350 feet. The slope of the outer side of the bar along the axis of the new channel is therefore 2.45 per cent.

As the dredge still drew after everything not absolutely essential to its work had been removed and placed on the shore about 0.3 foot more than the minimum depth, and as the side of the shoal was bluff, work had to be done with great caution. The vessel approached the bar from the seaward side, dropped the suction pipes in 22 feet of water, and went slowly forward until the forefoot touched the side of the shoal. It then went out to the dumping ground with the little load picked up. This process was kept up from the 23d to the 26th, inclusive; the amount of dredging done was 4,554 cubic yards for the four days.

When work was begun on October 28th (Monday) a new way was tried. The dredge moved forward as before and pumped until the forefoot touched bottom; then, instead of going to the dumping ground, it backed off into 22 to 26 feet depth of water and there dropped the partial load which it had on board. This operation was repeated 28 times during the day. When the dredge advanced the twenty-ninth time it crossed the shoal. The amount of material taken up on this day was 2,656 cubic yards. To be sure it was only shifted from one point of the channel to another, but it was economy of time to do this, because to remove this material later will require scarcely more than half a day's work. As the conditions of work during these last days of October were wholly abnormal, no attempt was made to keep any account of the cost of taking out this small quantity of 7,552 cubic yards.

Since November 1, 1895, work has gone on steadily and uninterruptedly as the weather would permit. The dredge should take out, under favorable conditions of working, 8 loads of 600 cubic yards per day. As the number of cubic yards dredged from November 1, 1895, to June 30, 1896, is 391,646, this amount of material should have been removed in 82 days—or taking the total number of loads, 665, and dividing it by 8, the number of loads per day under favorable conditions, the result is 83 days. Now the actual number of days of work is 115, hence each day of work gave an average of 0.74 of a good day.

The distinction made in this report between a day of work and a working day is this: A day of work is a day on which the dredge is at work, be the time employed greater or less; a working day is any day not a Sunday or legal holiday.

The number of working days between November 1 and June 30 was 203, hence a day of work was only 57 per cent of a working day. If we deduct from the working days those during which the dredge was under

repairs we have 175 days during which the vessel might have been at work; or each day of work was only 66 per cent of a day on which work might have been done had the weather permitted.

Arrangements had been made before the dredge arrived from the North for fuel and water, and the necessary ranges to mark the axis and sides of the channel had been established. The coal used was the Milldale, which cost $4.02 delivered on the dock near which the dredge tied up every night at the navy-yard. It has been a satisfactory fuel. The water was obtained mainly from one of the cisterns at the navy-yard, through the courtesy of the commandant of the yard. It was an economy in cost to obtain this water; furthermore, it was a great saving of time, as it would have been necessary otherwise to send the vessel to Pensacola at least twice a week.

The range marks for the axis of the channel are two skeleton towers, one 54 feet high and the other 30, from each of which a flag flies. The side lines of the cut are—one 75 feet to the east, the other 75 feet west of the axis. They are marked each by two poles on shore, each pole carrying a flag.

A careful account of the vessel's time and of all expenses connected with the work has been kept since it arrived. These are given in the following tables:

TABLE I.—*Cost of dredging at Pensacola Harbor, Florida, from November 1, 1895, to June 30, 1896.*

	November, 1895.	December, 1895.	January, 1896.	February, 1896.	March, 1896.	April, 1896.	May, 1896.	June, 1896.	Totals and averages.
Days of work	16	17	14	11	15	16	3	23	115
Sundays	4	5	4	4	5	4	5	4	35
Holidays	1	1	1	1	.....	.....	23	.....	4
Days spent in repairs	1	1	1	2	.....	.....	.....	.....	28
Bad-weather days	8	7	11	11	11	10	.....	3	61
Total	30	31	31	29	31	30	31	30	243
Cubic yards dredged	49,668	59,361	50,057	31,439	39,262	59,144	12,791	89,924	391,646
Number of loads	88	100	84	55	67	100	21	150	665
Cubic yards per load	564.30	593.61	595.90	571.62	586.00	591.44	609.10	599.49	588.93
Loads per day of work	5.50	5.88	6.00	5.00	4.47	6.67	7.00	6.52	5.78
Cubic yards per day of work	3,104.25	3,491.82	3,575.36	2,858.09	2,617.47	3,696.50	4,263.67	3,909.74	3,405.61
Cubic yards per working day	1,986.76	2,374.44	1,925.25	1,309.71	1,510.08	2,274.76	491.96	3,458.62	1,919.83
Cubic yards pumped per minute	17.74	18.76	18.55	17.88	15.84	16.15	17.57	17.31	17.36

DISTRIBUTION OF TIME FOR ONE LOAD.

	November, 1895.	December, 1895.	January, 1896.	February, 1896.	March, 1896.	April, 1896.	May, 1896.	June, 1896.	Totals and averages.
	Min.	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*	*Min.*
Loading	32.50	31.64	32.13	31.96	36.99	36.62	34.67	34.63	33.90
Turning	.19	2.10	1.32	3.42	.97	2.24	2.14	2.89	1.95
Raising suctions	1.96	2.69	1.75	1.67	1.70	2.55	2.48	1.08	1.91
Going to dumping ground	37	24.70	29.30	29.96	32.27	26.18	20.95	21.84	27.56
Unloading	8	7.46	7.88	7.96	8.05	7.27	7.33	6.91	7.49
Returning to cut	20.80	14.84	13.71	15.42	14.92	14.72	15.30	14.61	15.49
Total	100.45	83.43	86.09	90.39	94.92	89.58	82.87	81.96	88.30

TABLE I.—*Cost of dredging at Pensacola Harbor, Florida, etc.*—Continued.

DISTRIBUTION OF DAY'S TIME.

	November, 1895.		December, 1895.		January, 1896.		February, 1896.	
	Time.	Per cent.	Time.	Per cent.	Time.	Per cent.	Time.	Per cent.
	h. *m.*		*h.* *m.*		*h.* *m.*		*h.* *m.*	
From dock to cut.	0 39.4	6.26	0 39.94	7.07	0 39.71	6.60	0 39.55	6.45
Loading	2 58.9	28.41	3 6.12	32.92	3 12.79	32.02	2 39.82	26.07
Going to dumping ground	3 23.1	32.25	2 25.30	25.70	2 55.79	29.22	2 29.73	24.43
Unloading	0 44.2	7.02	0 43.88	7.76	0 47.29	7.86	0 39.82	6.50
Returning to cut	1 54.4	18.16	1 27.47	15.47	1 22.29	13.67	1 17.09	12.58
From cut to dock.	0 38	6.03	0 34.41	6.09	0 40.43	6.72	0 36.91	6.02
Lost raising suctions	0 10.8	1.71	0 15.86	2.81	0 11	1.83	0 8.36	1.36
Lost turning	0 1	.16	0 12.35	2.18	0 8.29	1.37	0 17.09	2.79
Lost by other causes					0 4.36	.71	1 24.63	13.80
Total	10 29.8	100	9 25.33	100	10 1.95	100	10 13	100

	March, 1896.		April, 1896.		May, 1896.		June, 1896.		Totals and averages.	
	Time.	Per cent.	Time.	Per cent.	Time.	Per cent.	Time.	Per cent.	Time.	Per cent.
	h. *m.*		*h.* *m.*		*h.* *m.*		*h.* *m.*		*h.* *m.*	
From dock to cut.	0 45.07	8.75	0 45.75	7	0 37.67	5.65	0 36.61	5.82	0 40.55	6.711
Loading	2 45.20	32.08	3 48.87	35.03	4 2.67	36.34	3 45.83	35.93	3 16.04	32.444
Going to dumping ground	2 24.13	27.99	2 43.63	25.05	2 26.67	21.97	2 22.43	22.66	2 39.34	26.371
Unloading	0 34.07	6.62	0 45.43	6.96	0 51.33	7.69	0 45.43	7.22	0 43.32	7.171
Returning to cut	1 6.73	12.96	1 32	14.08	1 47	16.03	1 35.26	15.15	1 29.56	14.822
From cut to dock.	0 43.13	8.37	0 47.69	7.30	0 50	7.47	0 46.83	7.45	0 41.75	6.909
Lost raising suctions	0 7.60	1.48	0 15.94	2.44	0 17.33	2.60	0 7.04	1.12	0 11.05	1.829
Lost turning	0 4.33	.84	0 14	2.14	0 15	2.25	0 18.87	3	0 11.30	1.870
Lost by other causes	0 4.74	.91					0 10.39	1.65	0 11.32	1.873
Total	8 35	100	10 53.31	100	11 7.67	100	10 28.69	100	10 4.23	100

COST OF WORK.

	November, 1895.		December, 1895.		January, 1896.		February, 1896.	
	Total cost.	Cost per cubic yard.	Total cost.	Cost per cubic yard.	Total cost.	Cost per cubic yard.	Total cost.	Cost per cubic yard.
Pay roll	$1,062.33	$0.0214	$1,065.00	$0.0180	$1,063.67	$0.0212	$1,065.00	$0.0339
Fuel	773.46	.0156	667.26	.0112	446.64	.0089	484.11	.0154
Water			35.00	.0007				
Rations	330.01	.0066	347.02	.0058	331.67	.0066	319.12	.0101
Supplies	80.08	.0016	149.48	.0025	156.31	.0031	161.62	.0051
Repairs			63.12	.0011	67.89	.0013	25.74	.0008
Tools	4.50	.0001			3.20	.0002	4.00	.0001
Total	2,250.38	.0453	2,326.88	.0393	2,069.38	.0413	2,059.59	.0655

	March, 1896.		April, 1896.		May, 1896.		June, 1896.		Totals and averages.	
	Total cost.	Cost per cubic yard.	Total cost.	Cost per cubic yard.	Total cost.	Cost per cubic yard.	Total cost.	Cost per cubic yard.	Total cost.	Cost per cubic yard.
Pay roll	$1,065.00	$0.0271	$1,064.17	$0.0180	$213.00	$0.0165	$1,102.33	$0.0123	$7,700.50	$0.0197
Fuel	565.05	.0144	686.13	.0116	182.40	.0142	883.69	.0098	4,688.74	.0120
Water	20.00	.0006	34.00	.0006	50.25	.0039			144.25	.0004
Rations	331.83	.0084	330.38	.0056	135.17	.0106	312.48	.0035	2,437.68	.0062
Supplies	182.88	.0047	156.06	.0026	143.89	.0116	155.03	.0017	1,185.35	.0030
Repairs	239.28	.0061	35.90	.0006	68.51	.0053	189.82	.0021	690.26	.0018
Tools	1.00		1.75		2.08	.0002	1.32		17.85	(*)
Total	2,410.04	.0613	2,308.39	.0390	795.30	.0623	2,644.67	.0294	16,864.63	.0431

* Inappreciable.

TABLE I.—*Cost of dredging at Pensacola Harbor, Florida, etc.*—Continued.

SUMMARY.

	November, 1895.	December, 1895.	January, 1896.	February, 1896.	March, 1896.	April, 1896.	May, 1896.	June, 1896.	Totals and averages.
Running expenses per cubic yard	$0.0453	$0.0393	$0.0413	$0.0654	$0.0614	$0.0390	$0.0623	$0.0294	$0.0431
Rent of dredge per cubic yard	.0251	.0211	.0260	.0382	.0331	.0220	.1017	.0145	.0260
Total	.0704	.0604	.0673	.1036	.0945	.0610	.1640	.0439	.0691
Coal consumption in tons	191.16	163	107	118	140	169	45	216	1,149
Cubic yards dredged per ton of coal	259.82	364.17	467.76	266.43	280.44	349.98	284.24	416.31	339.896
Water consumption in gallons	30,800	32,200	33,300	23,900	32,800	40,100	22,000	33,900	249,000
Cost of ration	$0.5024	$0.5331	$0.5094	$0.5240	$0.5098	$0.5244	$0.5519	$0.4959	$0.5276

TABLE II.—*Cost and expenditure of supplies used in dredging at Pensacola Harbor, Florida, from November 1, 1895, to June 30, 1896.*

MACHINIST'S SUPPLIES.

	November.		December.		January.		February.		March.		April.		May.		June.		Total.	
	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.
Acid, muriatic ..... ounces..					5	$0.15											5	$0.15
Bath brick ..... pounds..									½	$0.05			1	$0.10			1½	.15
Charcoal ..... do....			150	$30.00	125	25.00	100	$20.00	50	10.00	50	$10.00	50	10.00	50	$2.50	575	107.50
Cloth, emery ..... gross..							1	1.00	½	.50	½	.50	¼	.25	¼	.25	2½	2.50
Feeders, oil ..... number..													1	.25			1	.25
Glass:																		
Gauge ..... do....					1	.40	1	.40									2	.80
Water ..... do....											1	.40					1	.40
Graphite ..... pounds..	10	$4.00	5	1.25	3	.36	2	.24	5	.60	27	3.24	17	2.04			69	11.73
Grease, engine ..... do....	30	6.00	25	5.00	10	2.00	10	2.00	25	5.00	40	8.00	35	7.00	40	8.00	215	43.00
Hay, salt ..... do....					50	.62					50	.62					100	1.24
Ice ..... tons..			1½	12.00	¾	6.00	¾	6.00	¾	6.00	1¾	14.00	2½	18.85			8	62.85
Lacing, belt ..... feet..					30	.60	60	1.20			120	2.40	100	2.00			310	6.20
Lead:																		
Red ..... pounds..							10	1.50									10	1.50
White ..... do....					25	2.00							15	1.20	10	.75	50	3.95
Lime ..... barrels..	⅓	.33	1	1.15			½	.57	¼	.29	¼	.29	¼	.29	¼	.28	25/8	3.19
Lye ..... cans..	12	1.20	38	1.60	20	.84	20	.84	13	.58	15	.67	15	.67	20	.87	153	7.27
Matting, rubber ..... yards..							8	10.00									8	10.00
Oak ..... pieces..							1	1.00									1	1.00
Oil:																		
Coal ..... gallons..	5	.63	5½	.69	4	.50	4	.50	5½	.69	5	.62	6	.75	6	.75	41	5.13
Cylinder ..... do....	20	15.60	16	12.48	22	17.16	8½	6.63	19	14.82	22½	17.55	23	17.94	42	32.46	173	134.64
Engine ..... do....	28	17.36	22	13.64	35	21.70	17	10.54	43	26.66	18	11.16	10	6.51	40	24.80	213	132.37
Oilers ..... number..													5	.75	4	.60	9	1.35
Packing:																		
Eureka ..... pounds..					4	.88	10	2.20	2	.44			6	1.32	2	.44	24	5.28
Garlock ..... do....					1	.17							11	1.87	1	.17	13	2.21
Hemp ..... do....					8	3.20	6	2.40	5	2.00	6	2.40	6	2.40	10	4.00	41	16.40
I. C ..... do....							5	1.00	2	.40	2	.40	12	2.40	1	.20	22	4.40
Tuck's ..... do....					10	5.00	6	3.00	3	1.50	6	3.00	8	4.00	11	5.50	44	22.00
Paste, polishing ..... do....					1½	.62	4	1.66	4	2.00	3	1.50	3	1.50	10	5.00	25½	12.28
Rivets, copper ..... do....			5	2.00			1	.30			½	.15					6½	2.45
Rubber, sheet ..... do....					59	17.70											59	17.70
Soap ..... boxes..	¼	.75	1	2.50	½	1.20	½	1.20	½	1.05	1	2.10			½	.52	4¼	9.32
Solder ..... pounds..					5	.75											5	.75
Waste, cotton ..... do....	125	15.00	81	9.72	65	7.80	56	6.72	76	9.12	50	6.00	120	14.40	103	12.36	676	81.12

Wicking, cotton ..... pounds..																				
Zinc, white, in oil ..... do....					5	.22	6	.27	3	.13	7	.31	3	.90	4	1.20	28	3.03
															25	2.50	25	2.50
Total		60.87		92.03		114.87		81.17		81.83		85.31		97.38		103.15		716.61

ILLUMINATING SUPPLIES.

Burners, lamp ..... number..			6	$3.00													6	$3.00
Chimneys, lamp ..... do....			48	4.00	8	$0.67	10	$0.83	3	$0.75			2	$0.50			71	6.75
Lamps, petticoat ..... dozen..									1⅛	2.00			⅓	.50	¼	$0.50	1¼	3.00
Matches ..... do....			15	.75	16	.80	20	1.00	24	1.20	22	$1.10	39	2.10	10	.50	146	7.45
Oil:																		
Mineral ..... gallons..	32	$4.00	44	5.50	57	6.32	53½	6.69	46	15.75	21	2.62	27½	3.44	22½	2.81	303½	37.13
Signal ..... do....	15½	10.08	23	14.95	15	9.75	24½	15.92	15½	0.07	21	13.65	26	16.90	26	16.90	166½	108.22
Wicks, lamp ..... number..				1.15	4	.05	4	.05	3	.30	2	.02	4	.04	3	.03		1.64
Trimmers, lamp ..... do....									1	.75							1	.75
Total		14.08		29.35		17.59		24.49		20.82		17.39		23.48		20.74		167.94

MISCELLANEOUS SUPPLIES.

Bath brick ..... pounds..											½	$0.05					½	$0.05
Brooms ..... number..	7	$2.63	1	$0.37	3	$1.12	5	$1.87	2	$0.75	8	3.00	6	$2.25			32	11.99
Brushes, scrub ..... do....	6	1.50	2	.70			2	.70	1	.35	2	.70	2	.70	1	$0.35	16	5.00
Buckets ..... do....															4	1.00	4	1.00
Cloth, oil ..... yards..							2½	.75									2½	.75
Hose, rubber ..... feet..					20	3.80											20	3.80
Line, halyard signal ... pounds..					8	3.20											8	3.20
Lead, white ..... do....	12½	1.00	12½	1.00			25	2.00	30	2.15	12½	.94	20	1.50			112½	8.59
Marlin ..... do....							2	.40	4	.60	2	.30	2	.30			10	1.60
Mops ..... number..															1	.50	1	.50
Oil, boiled ..... gallons..							2	1.20	1	.60	7	3.95					10	5.75
Paint, black ..... gallons..			5	6.25							3	3.75					8	10.00
Pearline ..... dozen..			2½	1.25	3	1.50	2½	1.25	2	1.00	2	1.00	4½	2.40	3	1.50	19	9.90
Rope, manila ..... pounds..							329	28.79	671	57.03	210	17.85	48	4.08	64	5.44	1,322	113.10
Sapolio ..... dozen..			⅓	.33	⅝	.83	1½	1.50	1	1.00	2	2.00	1	1.00	1	1.00	7	7.69
Soap ..... pounds..			60	3.20			75	3.00	60	2.10	72	2.52	66	4.50	60	2.10	393	17.46
Soap, toilet ..... cakes..									12	1.00					12	1.00	24	2.02
Tacks, copper ..... pounds..					1	.40							1	.30			2	.70
Toweling ..... yards..					10	1.00	10	1.00	10	1.00	12	1.20			10	1.00	52	5.20
Turpentine ..... gallons..									1	.65	4	2.60					5	3.25
Hauling freight				15.00		12.00		13.50		12.00		13.50		6.00		17.25		89.25
Total		5.13		28.10		23.85		55.96		80.23		53.36		23.03		31.14		300.80

TABLE II.—*Cost and expenditure of supplies used in dredging at Pensacola Harbor, Florida, from November 1, 1895, to June 30, 1896*—Continued.

TOOLS.

	November.		December.		January.		February.		March.		April.		May.		June.		Total.	
	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.	Quantities.	Cost.
Blades, hack-saw.....number..	.....	.....	.....	.....	3	$0.75	4	$1.00	4	$1.00	3	$0.75	1	$0.08	4	$0.32	19	$3.90
Handles, maul.....do....	.....	.....	.....	.....	3	.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3	.45
Scoops, coal.....do....	3	$4.50	.....	.....	2	2.00	3	3.00	.....	.....	1	1.00	2	2.00	1	1.00	12	13.50
Total	.....	4.50	.....	.....	.....	3.20	.....	4.00	.....	1.00	.....	1.75	.....	2.08	.....	1.32	.....	17.85

Table II is merely supplementary to Table I. It gives an idea of the supplies which will be needed, probably, where dredging operations are to be carried on. It must not be accepted absolutely. It is only intended to be indicative. It will be of use, probably, to an officer who is about to begin operations in his district with a plant which he controls; after work shall have been under way a couple of months his experience will show him where changes can be made to advantage.

It was not practicable to tabulate or itemize the repairs carried in Table I. Not more than half a dozen items are repeated where more than a hundred exist. The largest items are:

Repairing leak in boiler (December, 1895)	$41.18
Repairing leak in boiler (March, 1896)	47.40
Repairing smokestack (January, 1896)	52.11
Repairing smokestack (March, 1896)	39.50
Repairing pumps (March, 1896)	104.86
Total	285.05

From these figures the value of the items runs down to 12 cents for a pound of wire nails.

The total current expenses from November 1, 1895, to June 30, 1896, are $16,864.63. The number of cubic yards dredged during the same time is 391,646. This gives an average of 4.31 cents as the price of dredging a cubic yard, running expenses alone included.

There are other expenses incurred in such operations which can hardly come under the head of current expenses, inasmuch as they have to be incurred only at comparatively long intervals. Such are the replacing of important parts of machinery; providing new bushings and stern bearings for propellers; renewing cranks of main engines; straightening and aligning shafts, etc. Many such repairs have been made; their cost has been borne by the appropriation for improving harbor at Pensacola, because it was desired to present the worst probable case in the cost of this sort of dredging at that place.

A pipe line had to be laid to supply the dredge with water; fenders had to be built to hold the vessel away from the stone wall of the dock against which it lies; ranges had to be erected. Collecting all items of this sort we have:

Fixtures for main pump	$360.00
Suction drag	225.20
Sleeves and bushings for propeller shafts	295.00
2 lengths suction hose	436.00
2 safety valves	220.00
Water pipe and connections	377.62
Dock fenders	139.00
Chafing fenders	4.00
Constructing beacons	272.20
Repairing beacons	9.75
General repairs on dredge	100.18
Repairs of machinery	225.04
Machine fittings	46.95
Furniture	47.44
Rope, manila	127.37
Rope, wire	53.58
Tools	21.25
Hauling machinery	6.00
Total	2,996.58

Deduct from this the following items transferred to current expenses:

Rope	$96.78	
Machinery fittings	9.75	
Current repairs	18.47	
		125.00
There remains a total of		2,871.58

It was noticed in the early spring that the vessel was greatly in need of a thorough overhauling. Authority was granted to send the vessel to New Orleans to have it docked and put in good repair. It started for New Orleans on May 6 and returned on May 28, having been gone twenty-three days. The cost of the repairs and the expenses of the trip were as follows:

Docking, repairing, cleaning, and painting bottom of vessel, calking wherever necessary, and putting afloat again	$1,411.94
Repairing, cleaning, and putting in order main engines, pumping engines, and auxiliary engines, putting in new sleeves and bushings for propellers, aligning propeller shafts, etc	992.91
Pipes and fittings	117.99
Condenser tubes	39.90
Springs and valves for air and water cylinders	40.80
Paints and sundries	121.25
Pay of crew	852.00
Rations	225.05
Fuel	153.40
Total	3,955.24

As stated above, the regular account of the cost of dredging was not begun until November 1, 1895. There were expenses in connection with bringing the vessel from New York to Pensacola, and in doing a little dredging in October. These are:

Pay roll October 7 to October 31	$1,035.01
Pilotage between Savannah and Pensacola	260.98
Fuel	945.28
Water	20.56
Supplies	26.43
Telegrams	1.63
Total	2,289.89

Collecting all these items we have:

Current expenses November 1 to June 30	16,864.63
Expenses not current	2,871.58
Expenses docking, overhauling machinery, etc	3,955.24
Expenses before November 1	2,289.89
Total	25,981.34
Add rent of dredge	11,250.00
Grand total	37,231.34

It was part of the agreement by which the *Gedney* was loaned for this work that $100 should be paid for every working day to cover cost of repairs, etc. When the first payment was made, December 31, 1895, Colonel Gillespie reduced the number of days 50 per cent in view of all repairs needed to that date having been paid for by the appropriation for Pensacola Harbor.

When the second payment was tendered, April 30, 1896, on the basis of the first settlement, Colonel Gillespie suggested that it would be well to wait for a final settlement until the dredge should return to New York. No accurate statement of this item of expense can be made now. As it is necessary to have something on which to work, it will be assumed here that the basis of the first settlement will stand. There were in October 22 working days, and from November 1 to June 30 there were 203, a total of 225. Half time gives 112½ days. At $100 per day the rent of the dredge becomes $11,250, of which $10,150 belongs to the period from November 1 to June 30.

The data for determining the cost of dredging are now complete.

The current expenses from November 1 to June 30 are $16,864.63; the work done is 391,646 cubic yards; hence the current expenses per cubic yard amount to $\frac{\$16,864.63}{391,646}=\$0.0431$.

The rent of the dredge during the same dates is $10,150, or per cubic yard $\frac{\$10,150}{391,646}=\$0.0259$.

The general expenses are $2,871.58, or per cubic yard $\frac{\$2,871.58}{391,646}=\$0.0073$.

The docking, etc., cost $3,955.24, or per cubic yard $\frac{\$3,955.24}{391,646}=\$0.0101$.

Taking these items together we have—

Current expenses	$0.0431
General expenses	.0073
Special expenses	.0101
Rent	.0260
Total per cubic yard	.0865

If the item of rent be excluded, the cost per cubic yard would be only $0.0605.

In the report in support of the project for the expenditure of $100,000 appropriated for Pensacola Harbor by the river and harbor act of 1894, sent to the Chief of Engineers October 22, 1894, this statement was made: "There is no doubt that with a well-equipped suction dredge of the proper size dredging can be done across the Caucus Shoal for not more than 6 cents per cubic yard, and probably for much less." The actual cost has exceeded the estimate by eight-tenths of 1 per cent.

The estimate of October 22, 1894, did not consider any question of rent, as the report was in support of a project for a special dredge for this harbor. It was based on work going on year in and year out, and not on work done mainly during the worst season of the year.

The past winter was one of the most unfavorable known for such work, mainly on account of the great amount of northeast winds. The percentage of this wind for fifteen years is 14.9; during the past winter it was 21. The best wind for dredging is the north. During the past winter this wind was 14.3 per cent, as against 17.8 per cent, the average proportion for fifteen years.

The weather reports for the month of May showed, almost invariably, favorable conditions for work. The month was practically lost, as the dredge was at New Orleans or Pensacola under repairs during all but five working days.

In order to make the case against dredging as strong as possible, every day that the dredge went out was called a day of work, no matter how little was accomplished. For example, the 9th, 12th, and 31st of December are all counted as days of work, although the work done was but 440 cubic yards on the first day, 484 on the second, and 273 on the third; in all, 1,197 cubic yards, or just one-fourth of a good day's work.

There was also the serious disadvantage of trying to work in a shallow channel, and narrow withal. Many days were lost because there would have been danger of losing the vessel, had work been undertaken, by running it ashore on one side of the cut or the other.

It may be doubted, therefore, whether such unfavorable conditions will be met again at this point.

The largest day's work was done on May 29, when 4,968 cubic yards were taken out in eight loads. The best pumping was done during the afternoon of January 4, when the maximum performance, 25.2 cubic yards per minute, was made on one load; the minimum was 23 cubic

yards per minute and the average for the afternoon was 24.18. No work was done in the morning. The smallest output for one load was on February 17, it being but 12.1 cubic yards per minute for one load. The average rate of pumping for the entire season was 17.36 cubic yards per minute.

In examining Table I, one point comes forward very prominently. This is the great proportion of time lost in going to and returning from the dumping ground. The average distribution of time per load, that is, from beginning to take in one load until beginning to take in the next, shows that it required 27.56 minutes to go out and 15.49 minutes to come back. The period of unloading should be counted with these, as the load is dropped while the vessel is turning to come back. The two items of going out and returning count up 43.05 minutes; adding the third the total is 50.54 minutes. This is 57.23 per cent of the total time, whereas the dredging lasts but 38.39 per cent. In other words, the dredging time is to the transportation time as 2 to 3. This is a great element of cost in this class of work.

If the total work of the day—that is, from the time vessel starts from its dock in the morning until its return in the evening—be analyzed, it will be found that the time spent in dredging during the day is 196.04 minutes, while that spent in running out, unloading, and returning to the cut is 292.22 minutes. The ratio between these figures is still 2 to 3, with an error of only two-thirds of 1 per cent.

If the percentage of each of the various operations which go to make up a day's time be multiplied by 6.05, the cost in cents per cubic yard dredged, there will be obtained the cost of each operation per cubic yard. This gives the cost of digging as 1.963 cents per cubic yard, whereas the cost of going to the dumping ground, of unloading, and of returning to the cut is 2.943 cents. This result can be changed only by increasing the capacity of the dredge.

The cost of each division of the day's time per cubic yard is:

	Cents.
From dock to cut	0.406
Loading	1.963
Going to dumping ground	1.595
Unloading	.434
Returning to cut	.898
From cut to dock	.415
Lost raising suctions	.111
Lost turning	.113
Lost by other causes	.113
Total	6.048

The results of the work done are as follows: Total amount of material dredged, 399,198 cubic yards. When dredging was begun the least depth on the axis of the channel to be dug was 14.4 feet. The present depth at the same point is 23.7 feet, while the least depth along the axis is 23 feet. Where the shoalest point now is there was before dredging 21 feet of depth. This depth of 23 feet has a width of 55 feet. Dredging was carried on between two lines parallel to the axis, one 75 feet east, the other 75 feet west thereof. The average depth at the beginning on the east range was 16 feet; it is now 19 feet. The average depth on the west range was 15.5 feet; it is now 19 feet.

The amount of work done by the dredge in June, 89,934 cubic yards, and the number of days of work, twenty-three for the same month, are a fair average of what could be expected from the *Gedney* during the summer months. Mr. J. E. Turtle, assistant engineer in local charge

of Pensacola Harbor, states that "the dredge operated by Rittenhouse Moore lost not more than three days on account of bad weather from May 15 to August 15." The dredge was at Pensacola during eight months. Of these one month was a good working month, six were poor working months, one was spent almost entirely in repairs, and this one, if judgment can be based on official weather reports, would have been quite as good as June.

Add to the unfavorable conditions of weather the fact that during the first six weeks of work the vessel never had enough water under the keel to carry a full load even when the sea was perfectly calm, and that many days were lost when work might have been done had there been sufficient depth of water to prevent the dredge from grounding, I think that it may be said safely that such disadvantages for work are not likely to be met again.

Before leaving the subject of dredging I desire to mention to the Department the many obligations under which this work is to Commander H. C. Whiting, United States Navy, commandant of the Pensacola Navy-Yard, who was deeply interested at all times in the success of the work, and who gave every assistance which the facilities of the yard afforded to aid in carrying it on. His unfailing courtesy was the means of avoiding many items of expense and much loss of time.

SURVEY OF THE ENTRANCE TO PENSACOLA HARBOR.

This survey was begun July 8, 1895. It included the entrance and the shoals in front as far as the 6-fathom curve. The map was completed and submitted October 7, 1895. It is on a scale of 1 inch to 500 feet, and has contours taken at every foot. The survey and map cost $2,925.29. The area covered was 11.8 square miles, hence the cost per square mile was $244.34.

SURVEY OF THE WATER FRONT OF THE CITY OF PENSACOLA.

This survey was made for the purpose of locating harbor lines in the vicinity and along the water front of the city. Work was begun November 1, 1895; the map was completed May 18, 1896.

The survey was to include the shore line of the north side of Pensacola Bay with all the wharves, and the principal streets of the town. As a complete topographic survey had been made the year before by the Coast and Geodetic Survey, a tracing of this was obtained. This survey was used as the basis of our work, and our triangulation points were checked by it. A base line was laid down. It is marked by concrete posts, one at each end of the line. A copper plug in each post gives the exact terminal. The length of the base is 1,900.09 feet. Soundings were taken at first from a rowboat; this was found to be too slow. Authority was then asked for and granted to hire a naphtha launch. This increased greatly the rate of work. The soundings were located by two transits on shore. The field work was completed February 20, 1896. The total number of soundings was 13,898. The cost of the survey and making the map was $2,775.52. The area covered by the survey is 9.90 square miles, hence the cost per square mile is $280.36. The increase of cost of this survey over the one at the entrance to the harbor is explained by the fact that it was made in winter, when much time is lost by reason of bad and rough weather, while the other was made in summer, when the sea is generally smooth.

GENERAL REMARKS.

One result of the year's work is to prove the practicability of dredging at Pensacola at a reasonable cost. A second result is a cut through the Caucus Shoal, which, while having a better depth than that in the old channel, has not the width necessary to make it navigable. It is essential for the commerce of the port that this channel be opened to its full width and depth—300 feet and 30 feet, respectively—as recommended by the Board of Engineers March 9, 1896.

It must also be borne in mind that Pensacola Bay has strategic features and value possessed by no other harbor on the Gulf of Mexico.

It would be well if the *Gedney* could be returned to Pensacola after having finished at New York the work which it will have to do this summer. It could then continue the opening of the new cut while the dredge which has been recommended for Pensacola is under construction.

RECOMMENDATIONS AND ESTIMATES.

It is recommended that a dredge of good power be put under construction at as early a date as possible, in agreement with the recommendation of the Board of Engineers on Pensacola Harbor dated March 9, 1896. It is proposed to give this dredge a bin capacity of 1,200 cubic yards and pumps of sufficient power to fill the bins in half an hour at most.

It is further recommended that the dredge *Gedney* be allowed to return to Pensacola after having finished work which it will have to do at New York during the present summer, and to remain there until relieved by the new dredge, unless it be needed for work at New York.

The cost of dredging is estimated at $3,300 a month, or, say, $40,000 a year in round numbers, as an extreme outside figure.

Since writing the above, and before mailing this report, the severe northeasterly gale of July 7, 1896, made a breach on the north side of the north jetty built for the protection of the shore line west of the entrance to the bay.

This breach should be closed by a stone dike made sufficiently strong to prevent the accident happening again. If a new channel should form to the westward of the jetties, all the work done in digging a channel across the Caucus Shoal will have been lost. Hence the necessity of protecting the shore line to the northward of the north jetty. To build this protection will require $100,000.

Hence the total amount needed for Pensacola Harbor for the year ending June 30, 1898, is $140,000.

Money statement.

July 1, 1895, balance unexpended	$96,978.50
Amount appropriated by act of June 3, 1896	200,000.00
	296,978.50
June 30, 1896, amount expended during fiscal year	42,066.07
July 1, 1896, balance unexpended	254,912.43
July 1, 1896, outstanding liabilities	2,367.42
July 1, 1896, balance available	252,545.01
Amount that can be profitably expended in fiscal year ending June 30, 1898	140,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

Abstract of bids received and opened by Maj. F. A. Mahan, Corps of Engineers, April 29, 1896, for furnishing and delivering cement, broken stone, etc., at United States Engineer Wharf, Pensacola Harbor, Florida.

No.	Class	A.	B.		C.	D.				E.
	Name and address of bidder.	Cement, per barrel.	Ordinary broken stone, per cubic yard.	Granolithic broken stone, per cubic yard.	Pebbles, per cubic yard.	Beams and steel connections, per pound.	2-inch steel bolts, each.	1¼-inch steel bolts, each.	Iron bolts, per pound.	Bronze door hinges, hasps, staples, and shanks, per pound.
1	J. B. McWhoter, Mobile, Ala	$2.287	.....	.....	$4.444	.....	.....	.....	.....	.....
2	Chas. G. Smith & Son, Washington, D. C	.....	$2.73	$2.92	.....	.....	.....	.....	.....	.....
3	Sinclair & Babson, New York, N. Y	2.28	.....	.....	.....	.....	.....	.....	.....	.....
4	National Building Supply Co., Baltimore, Md	3.25	.....	.....	.....	.....	.....	.....	.....	.....
5	A. C. Danner, Mobile, Ala	2.53	.....	.....	.....	.....	.....	.....	.....	.....
6	Chas. M. Gilbert, Savannah, Ga	2.49	.....	.....	.....	.....	.....	.....	.....	.....
7	Watkins & Hardaway, Birmingham, Ala	.....	4.00	5.00	.....	$0.03½	$4.42	$2.80	$0.03	.....
8	Venable Bros., Atlanta, Ga	.....	5.25	6.25	6.25	.....	.....	.....	.....	.....
9	Wm. Gisriel, Baltimore, Md	.....	.....	.....	.....	.....	.....	.....	.....	$0.20

No. 1. Brand of cement, Alpha.
No. 3. Brand of cement, Alsen.
No. 4. Brand of cement, Porter or Kaiser.
No. 5. Brand of cement, Lagerdorfer.
No. 6. Brand of cement, Gibbs Double Ground.

REPORT OF BOARD OF ENGINEERS.

ARMY BUILDING,
New York City, March 9, 1896.

GENERAL: The Board of Officers of the Corps of Engineers, convened by Special Orders, No. 29, series of 1895, Headquarters Corps of Engineers, now consisting of Col. H. M. Robert, Col. G. L. Gillespie, Maj. C. W. Raymond, Maj. F. A. Mahan, Capt. W. M. Black, and Capt. O. M. Carter, reassembled in the Army Building, New York City, on March 9, 1896, as directed by Special Orders, No. 8, current series, Headquarters Corps of Engineers, all the members being present.

The preliminary report of the Board, dated August 20, 1895; reports of Major Mahan, dated October 15, 1895, and December 9, 1895, and oral statements of Major Mahan relating to the work now being done at Pensacola in accordance with the recommendations of the Board, contained in the preliminary report, having been considered, the following report is submitted:

1. The Board recommends that all funds now available be expended in continuing the work of dredging across Caucus Shoal.

2. If funds sufficient for the construction of a suitable dredge and for its operation for a period of at least two years be made available by the next river and harbor act, the Board recommends that such a dredge be built and a channel opened across Caucus Shoal at least 300 feet wide, having a least mean low-water depth of 30 feet, with such side slopes as the material will assume.

Until a channel be opened by dredging across Caucus Shoal, as herein proposed, the Board recommends that the question of constructing jetties for its economical maintenance be not further considered.

The existing conditions at the western end of Santa Rosa Island and near Fort McRee should, however, be maintained by the construction, if necessary, of suitable shore protection, which may be utilized as bases for jetties should their construction become imperative.

Respectfully submitted.

HENRY M. ROBERT,
Colonel, Corps of Engineers.
G. L. GILLESPIE,
Colonel, Corps of Engineers.
C. W. RAYMOND,
Major, Corps of Engineers.
F. A. MAHAN,
Major, Corps of Engineers.
W. M. BLACK,
Captain, Corps of Engineers.
O. M. CARTER,
Captain, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The following information has been furnished by Mr. Daniel G. Brent, collector of customs of the port of Pensacola, Fla.:

Exports to foreign ports		$3,805,589.00
Exports to coastwise ports		335,196.00
		4,140,785.00
Imports from foreign ports		35,198.33
		4,175,983.33
Duties on imports and miscellaneous collections		23,538.68
Vessels entering from foreign ports		333
Vessels entering from coastwise ports		142
		475
Vessels cleared for foreign ports		375
Vessels cleared for coastwise ports		122
		497
Vessels employed in traffic of port:		
Steam		30
Sail		132
		162

The coastwise exports consisted of:

Article.	Quantity.	Value.
Lumber.....feet B. M..	17,465,000	$174,650
Coal.....tons..	75,713	151,426
Pig iron.....do....	319.5	2,556
Shingles	2,188,000	6,564
Total	.....	335,196

In addition to the above there were shipped coastwise 1,600 tons of old cannon shells, etc., and 300 tons rock.

O 7.

IMPROVEMENT OF ESCAMBIA AND CONECUH RIVERS, FLORIDA AND ALABAMA.

DESCRIPTION AND CONDITION BEFORE IMPROVEMENT.

These two names apply to the same river, which is known by the name of the Escambia from the boundary line between the States of Alabama and Florida to the mouth of the river in Escambia Bay, an arm of Pensacola Bay, and the Conecuh north of the Florida and Alabama State line.

An examination of the part of the river lying south of the Alabama State line, a length of 100 miles, was made between the 19th and 28th of November, 1878. In this distance the width of the river is rarely less than 150 feet and often increases to 300 feet. The country through which it flows is, with but little exception, low, swampy, and subject to overflow for several miles on either side. At the mouth of the river, where it empties into Escambia Bay, there exists a bar on which the depth of water is not stated. The channel of the river was tortuous and was much obstructed by snags, logs, etc. There were also a few points to be cut off by means of dredging.

PROJECT.

The improvements suggested were to dredge a channel through the bar 150 feet wide and 5½ feet deep at mean low tide, to remove other obstructions and construct a few dikes, wing dams, and shore protection, so as to give a good navigable channel of a minimum depth of 5 feet throughout its entire length at ordinary low water. The original estimate of the cost of improvement was $87,430.

APPROPRIATIONS.

For Escambia River:

March 2, 1833	$5,000
July 2, 1836	5,500
June 14, 1880	8,000
March 3, 1881	5,000
July 5, 1884	3,000
August 2, 1882	12,000

For Escambia and Conecuh rivers:

July 5, 1884	$12,000
August 5, 1886	12,000
August 11, 1888	10,000
September 19, 1890	7,500
July 13, 1892	8,000
August 17, 1894	6,000
June 3, 1896	4,000
Total	98,000

OPERATIONS TO JUNE 30, 1895.

1880.—Nothing done.

1881.—A contract was made to dredge through the bar, at a cost of 47½ cents per cubic yard, with Mr. William A. Alexander, work to be begun May 24, 1881. On account of various delays no work was done during the fiscal year.

1882.—A channel 100 feet wide, 5½ feet deep at mean low water, and 3,240 feet in length, was dredged through the bar.

1883.—Work was confined to the part of the river near to and above the town of Brewton, Ala. The distance cleared of obstructions was about 4 miles, being where the obstructions were most numerous. Work was suspended in January on account of high water. The obstructions removed were: Two hundred and fourteen fallen trees, 506 snags, 49 deadhead logs, 185 hurricane stumps, 252 overhanging trees.

1884.—Eighty-five miles of snagging, removing overhanging and fallen trees, was done on the Escambia part of the river. An examination of the bar at the mouth of the river showed that the channel through it had shoaled to 4½ feet. On the Conecuh River the work of snagging was resumed July 18, 1883, and continued until the 1st of December. Work was carried on down to the Alabama and Florida State line, a distance of 29¼ miles, but no details are given.

1885.—Work consisted in the removal of snags and other obstructions from the channel and overhanging trees from the banks over a distance of about 71 miles. Fifteen thousand four hundred and seventy-two logs, snags, stumps, etc., were cut or removed. The operations extended over 71 miles of the Conecuh and 5½ miles of the Escambia.

1886.—Ten thousand nine hundred and forty-three logs, snags, and overhanging trees and 105½ cubic yards of rock were removed, clearing the river of obstructions for a distance of 140 miles.

1887.—Two snagging parties went over 99 miles of the river, doing the following work: Overhanging trees felled and cut up, 338; overhanging trees trimmed, 37; logs cut up on banks, 440; stumps cut level on banks, 245; logs and snags removed from the channel, 1,509; 45 cubic yards of rock removed.

1888.—The snag boat removed 2,998 logs and snags from the channel and 275 overhanging trees from the banks. A detached working party removed all rocks visible in the channel at low water over a section of the river not mentioned.

1889.—Work was done between the middle of July, 1888, and the middle of January, 1889, over 19 miles of the river lying between 81 and 100 miles from its mouth. Work began again in May, 1889. No details of what was accomplished are given. An examination made in April, 1889, showed that there had been a considerable shoaling of the channel over the bar, and that to restore it to 7 feet depth at mean low water would require the removal of 6,157 cubic yards of material.

NOTE.—It will be remarked that no project had been presented up to this time to increase the depth on the bar at the mouth from 5½ to 7 feet.

1890.—The snag boat was at work on the river until August 9, when it was allowed to drift down to the mouth of the river, which it reached on August 26. The snagging machinery was taken from the hold preparatory to using the hull of the boat for dredging purposes. A centrifugal pump, which had been ordered from Joseph Edwards & Co., New York, arrived on October 24, and was put immediately into place.

Dredging was done by towing the snag boat carrying the dredging machinery back and forth across the bar and emptying the dredged material into a bin built upon a barge hired for the purpose. Many delays took place; the tug could not be had all the time, and there was scarcely enough water for the towboat to get back and forth. This made the work slow and expensive. Between November 6 and December 19 a channel 60 feet wide and 6 feet deep at low water was secured. The amount of material removed was 2,353 cubic yards, but no cost of the work is given.

Work during this year, in addition to the dredging above mentioned, included 530 snags removed, 18 trees cut and removed, 11 cubic yards of rock and 14 cubic yards of gravel taken from the channel.

1891.—Work was not begun until May 18. How much was accomplished is not stated.

1892.—Work was continued from the beginning of the year until December 16, 1891, when high water caused it to be suspended. It was resumed on May 20, 1892. Work performed was 3,523 snags removed

from the channel, 56 overhanging trees from the banks, 144 stumps leveled, 1,015 logs cut on the banks, and 19 cubic yards of gravel removed from the channel.

1893.—Between January 29 and May 13 the snag boat was overhauled and rearranged, at a cost of $3,000, increasing greatly its efficiency. Work was done over a length of 40 miles of the river between the beginning of the year and December 12, 1892, when operations were suspended, to be resumed again on June 9, 1893. Much rain and consequent high water caused great loss of time, only seven working days being had in August and the same number in September. The work accomplished was 1,078 snags removed from the channel, 27 overhanging trees from the banks, 105 stumps cut level with the bank, and 241 logs cut up.

1894.—Work was done over a length of 71 miles of the river. It consisted in the removal of 365 snags and 8 logs from the channel, felling and cutting up 71 overhanging trees, cutting up 122 logs, and leveling 47 stumps, at a cost of $1,078.35.

1895.—The snag boat was overhauled and repaired. Active operations were begun on May 6, 1895, and between that time and the end of the year 22 trees had been felled and cut up, 30 felled and pulled back, 58 stumps leveled, 29 logs removed from drift piles, and 9 stumps and 120 snags removed from the river, at a cost of $708.11.

CONDITION OF IMPROVEMENT JUNE 30, 1895.

The entire object of this stream is to give a safe passage to the large quantity of timber and lumber cut along its course, and forming the main portion of the timber trade of Pensacola, Fla.

At the end of the year 1895 the river was in condition to admit safe passage to rafts of timber and logs on a stage of 2 feet above low water from a point 106 miles above its mouth.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1896.

Work was carried on from the beginning of the year to December 20, 1895. During this time 24 overhanging trees were felled and cut up, and 4 trimmed; 215 logs cut up and stumps leveled on bank; 368 logs removed from drift piles; 110 stumps, 1332 snags, and 43 logs removed from the river. The total cost of these operations was $2,757.40. Work extended over 56 miles of the river in the part most dangerous to rafting and most difficult to maintain. The passage of rafts has now been made safe.

CONDITION OF IMPROVEMENT JUNE 30, 1896.

The river is now in good condition for rafting.

RECOMMENDATIONS AND ESTIMATES.

It is recommended that the use of the snag boat be continued to keep the stream clear of obstructions. The small appropriations made for this stream, which carries a commerce of $2,000,000 and over a year, are not sufficient to work over more than a restricted part of the stream each year; $6,000 should be provided for snagging on this river for the next fiscal year.

The condition of the bar at the mouth of the river is such that tugs can not cross it to go inside to take out the rafts as they come down.

It is necessary, therefore, to float the rafts out of the river, across the bar, and tie them up in the bay so that tugs can reach them at some subsequent time. When rafts are tied up in this way in the bay there is always danger from unexpected storms carrying them away, breaking them up, and scattering the timber. If tugs could cross the bar the rafts could be tied up inside the mouth of the river in safety. To dredge a proper channel through the bar will cost $12,000; this will make a channel 100 feet wide by 7½ to 8 feet deep.

Money statement.

July 1, 1895, balance unexpended	$4,591.70
Amount appropriated by act of June 3, 1896	4,000.00
	8,591.70
June 30, 1896, amount expended during fiscal year	4,115.75
July 1, 1896, balance unexpended	4,475.95
July 1, 1896, outstanding liabilities	187.66
July 1, 1896, balance available	4,288.29
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	6,000.00

O 8.

IMPROVEMENT OF ALABAMA RIVER, ALABAMA.

DESCRIPTION AND CONDITION BEFORE IMPROVEMENTS WERE BEGUN.

The Alabama River is formed by the junction of the Coosa and Tallapoosa rivers, which come together at a point 14 miles above Montgomery, Ala. The general direction of the stream is southwest from the junction of its affluents to Montgomery; from Montgomery to Selma, Ala., it is nearly west; from Selma to the junction of the Alabama and Tombigbee rivers it is slightly west of south. The total length of the river is approximately 310 miles.

The normal width of the Alabama from Wetumpka to Selma is from 500 to 600 feet; from Selma to its junction with the Tombigbee it is from 700 to 800 feet.

As the river is made up of a series of pools and shoals alternating with each other, its depth varies greatly. More than 25 feet has been found in some of the pools, and less than 2 feet on some of the shoals.

The fall of the river is unknown. No survey has ever been made. No continuous line of levels has ever been run. Its discharge has never been determined. There are no data available on which to found a systematic and comprehensive scheme of improvement.

The original condition of the river was very bad. It was so obstructed by logs, snags, and fallen trees in the channel, by overhanging trees on the banks, and by bars and shoals on many of which the low-water depth was only 2.5 to 3.5 feet, that navigation was difficult and dangerous at all times; it was practicable only by day during the low-water season. Long detentions were frequent at the shoals below Selma, and traffic was suspended between Selma and Montgomery when the water was low.

PROJECT.

The original project for the improvement of this stream (see Report of the Chief of Engineers for 1876, Part I, p. 498) looked toward obtaining a channel 4 feet deep at low water, with a minimum width of 200 feet. This result was to be obtained by removing logs and snags from the channel and overhanging trees from the banks; by cutting through rock reefs and gravel bars; by blasting and dredging; by deepening the channel across sand shoals and bars by works of contraction; by stopping the caving and washing of the banks by shore protection. The estimated cost of carrying out this project was $229,741.

First amendment.—The above project was amended (see Annual Report Chief of Engineers for 1891, Part III, p. 1761). The amended project differs from the original only in the depth to be obtained. This was put at 6 feet instead of 4 feet. The estimated cost of the amended project was placed at $386,251. Snagging operations and the maintenance of the increased depth when obtained were estimated to cost $10,000 a year.

APPROPRIATIONS.

June 18, 1878	$25,000	August 11, 1888	$20,000
March 3, 1879	30,000	September 19, 1890	20,000
June 14, 1880	25,000	July 13, 1892	70,000
March 3, 1881	20,000	August 17, 1894	50,000
August 2, 1882	20,000	June 3, 1896	40,000
July 5, 1884	10,000		
August 5, 1886	15,000	Total	345,000

OPERATIONS TO JUNE 30, 1895.

1879.—Work was begun on this river in 1878. A steamboat and quarter boat for 30 men, a barge for transporting materials, and a small office boat comprised the equipment. The steamboat *Seawell* was fitted up with a derrick, capstan, and other appliances needed in snagging, and began work August 19. The quarter boat went to work one week later. The barge and office boat were placed on the river May 12, 1879.

Work was begun at the place known as the Cut-off. This is an outlet of the Alabama River to the Tombigbee, about 25 miles by the former river from their junction. This cut-off was closed during the year, and a bar which had formed in the Alabama River near its mouth was reduced in size so that where the depth of water was but 2 feet at low water it was increased to 4 feet. Although the method of closing the cut was very interesting, it is too long to repeat here. It will be found on pages 827, 828, and 829, Part I, Report of the Chief of Engineers for 1880.

Three hundred and twenty logs were removed from the channel for a distance of 50 miles above the mouth of the river.

1880.—The dam across the Cut-off was completed. A wing dam 350 feet long was extended from the main dam into the river to prevent scour along its base, and also to concentrate its current so as to scour out the channel over the bar in the river below. At Haynes Island, 90 miles above the mouth of the river, three chutes were closed by brush dams, and two wing dams were built, and all snags removed from the channel. Two thousand four hundred and eighty-two running feet of dams and wing dams were required at this point, and the channel was deepened by the dam from 2.5 to 4 feet at low water. The left-hand chute at Hobbs Bar was closed by a riprap dam 435 feet long, 6 feet high. Six hundred cubic yards of rock and 800 cubic yards of gravel were used in its construction; the depth over the bar in the

main channel was increased from 3 to 4 feet. The right-hand chute at Yellow Jacket Bar, 169 miles below Montgomery, was partly closed. At Gardner Island, 65 miles below Montgomery, one of the worst places on the river, snags were removed and mattresses of cane and piles were collected and prepared for closing the left-hand chute; 490 snags were removed during the season.

1881.—The left-hand chute at Gardner Island was closed during the month of August. The work of constructing a dam at Cox Bar, 15 miles below Montgomery, was begun; operations were much retarded by a rise in the river, and were finally suspended in September. Work was begun at Hadnot Bar, 14 miles below Montgomery; by the time the material could be prepared the river had fallen sufficiently to resume operations at Cox Bar; another rise (of 8 feet) caused the removal of the force up to Three Chutes, 2 miles below Montgomery. The right-hand chute, at Three Chutes, was closed successfully the latter part of September, 1880. Work was completed at Cox and Hadnot bars during October; snags and logs were removed at Monack (Manack) Island. A break occurred in the dam across the Cut-off in October, 1880; the breach was finally closed during the last two months of the fiscal year, although the dam was not wholly completed.

1882.—The closing of the break in the dam was completed early in the year. The right-hand chute of Yellow Jacket Bar was closed by completing the rock dam left unfinished two years before. A breach was found in the dam built to close the left-hand chute at Hobbs Island. A new site was selected farther down the chute and an entirely new dam was built and the chute again closed. The dam across the left-hand chute at Gardner Island was completed during 1881, but owing to the formation of a large sand bar in the main river just below the mouth of Big Mulberry Creek, which almost entirely closed the river to navigation, the entire force was ordered there and a passage cut through the dam. This afforded immediate relief, and no further trouble was met with during the remainder of the low-water season. The entire river from Selma to the Cut-off was worked over; all dangerous logs and snags were removed, and the chutes and close places were cleared of overhanging timber.

1883.—Operations during this year consisted in snagging and cutting overhanging trees, except at the Cut-off, where 12 piles were driven, 80 running feet of mattresses sunk, and 200 running feet of bank protection laid down; 1,584 snags and logs were removed and 2,744 overhanging trees were cut.

1884.—Owing to lack of funds, no work was done beyond such as could be accomplished with the snag boat; 2,965 snags and logs were taken out of the river and 2,037 overhanging trees were cut.

1885.—What little work was done during 1885 was confined to snagging operations, principally between Montgomery and Selma in the vicinity of Gardner Island. Report for this year gives no idea as to the amount of work done.

1886.—Snagging operations were all that was done during this year. The annual report gives no details.

1887.—One thousand six hundred and eighty-eight logs were removed from the channel, and 738 overhanging trees, stumps, and drift logs were felled and cut up or trimmed.

1888.—One thousand three hundred and thirty logs and snags were removed from the channel, and 533 overhanging trees from the banks.

1889.—Two thousand two hundred logs and snags removed from the channel, 2,261 stumps cut level with the banks, 2,478 overhanging trees cut and removed, and 1 wreck removed constituted the work for this year.

1890.—Work was still confined to snagging and similar operations; 3,416 overhanging trees removed from the banks, 391 logs and drift cut up on banks, 411 stumps leveled, 1,706 logs and snags removed from the channel. The snag boat worked over a distance of 293 miles; ran a total distance of 1,157 miles; consumed 186½ cords wood and 39½ tons of coal. The force employed, including officers and men, averaged 15.3, and was engaged 162 days, with a loss of time on account of high water of 11.6 days.

1891.—The snag boat cleaned out 103½ miles in length of the river, and then, on account of continued high water, went to Montgomery and laid up during the winter. Work was resumed May 20, 1891, and the river cleaned out between Montgomery and the junction of the Coosa and Tallapoosa rivers. Some partial repairs were made at the upper end of the broken jetty just below Haynes Island.

1892.—Little more than snagging was done during this year. Five hundred and thirty two overhanging trees were felled and cut up, 65 were pulled back and cut up, and 19 were trimmed; 27 logs were removed from the banks, 45 fallen trees on banks were cut up, 8 stumps leveled, 37 logs and snags removed from the channel, and 277 trees removed from landslips. In addition to this work, there were 25 cubic yards of bowlders removed from the river, 1,550 cubic yards of gravel excavation made by raking, and 181 running feet of rock-and-brush jetty built.

1893.—Works of contraction, for cutting away bars, were built at Three Chutes, 2 miles below Montgomery; at Hadnot Bar, 14 miles; Manack Island Bar, 19 miles. A break in the dam at the head of Gardner Island was closed. Large bowlders projecting from the bank at four different landings were removed, as they were dangerous to boats trying to get in. Two thousand one hundred and forty-five overhanging trees were felled, cut up, pulled back, or trimmed; 133 logs cut up on banks; 65 stumps leveled, and 758 snags removed from the river. Four thousand two hundred and eighty-one running feet of dams was built and 335 running feet of shore protection.

1894.—Contraction works were put in or repaired at Three Chutes, Cox Bar, Hadnot Bar, Manack Island, Tyus Bar, Silver Creek Shoals, Shackleford Bar, Carter Shoals, and Aberdeen Bar. Five hundred and ninety-two overhanging trees were removed and trimmed, 1,050 bushes cut up, 121 logs on banks and 1 stump cut level, 117 logs, snags, and stumps removed from the channel. The contraction works at the various points mentioned had done their work well, giving increased depths in the channel varying from 1½ to 3½ feet, and making them navigable for vessels in the trade of the Alabama River.

1895.—Contraction work was done at Shackleford Bar, Carter Shoal, and Tate Shoals. Snagging operations resulted in the removal and trimming of 325 overhanging trees, cutting up 156 logs on banks, leveling 10 stumps, and removal of 315 snags and logs from the channel.

No special mention has been made of the method of construction adopted for these works of contraction, because they are all similar to that put in at Tate Shoals, which is described fully in the report of operations for the present fiscal year.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1896.

The snag boat worked over the part of the river between Moseleys Landing, 124 miles below Montgomery, and Scotts Bend, 5 miles above, from July 20 to August 17. All visible logs and snags were removed from the channel and all overhanging timber in the chutes was cut down or trimmed. The snag boat worked over the rest of the river between August 23 and September 9.

The cost of the snagging operations was:

Engineering, superintendence, and labor	$864.94
Subsistence	170.81
Fuel	162.00
Engine supplies and lights	19.90
Stationery	20.20
Medicine	5.90
Total	1,243.75

The work done was:

Overhanging trees felled and cut up	437
Overhanging trees felled and pulled back	40
Overhanging trees trimmed	108
Drift pile removed	1
Stumps cut level on banks	28
Logs cut up on banks	39
Logs removed from drift piles	17
Stumps removed from river	25
Large snags and trees removed from river	237
Logs removed from river	38
Part of wreck removed	1
Length of river over which work was done ..... miles..	296

Boat ran 524.5 miles and burned 14½ tons of bituminous coal and 86 cords of wood.

The snag boat and the towboat *Coosada* then took all the plant except the boats left with the survey party (to be spoken of hereafter) to Tate Shoals, where work had been suspended on December 15, 1894. The construction of the dike was continued as it was begun. Two rows of piles, 25 to 30 feet long, 12 inches in diameter, with a penetration of 15 to 18 feet, are driven in two rows 8 feet apart, the piles in each row being 8 feet between centers. Bundles of cane, 25 to 30 feet long and 1 foot in diameter, are laid transversely to the rows of piles to a thickness of 2 feet. This gives the base of the dike a width of 25 feet at least. The space between the rows of piles is then filled with bundles of brush or cane, laid longitudinally, to a depth of 5 feet. The whole thickness of the cane and brush bundles is then compressed to the low-water line. Rock is piled carefully on top of the brush until the crest of the dike reaches a uniform level of 4 feet above low water. The ends of the transverse bundles of cane are also well weighted with heavy rock.

The dike starts from the right bank under an angle of about 60 degrees with the axis of the river. It maintains this direction for about one-third of the width of the river, where it curves downstream until it becomes parallel with the direction of the current. The part of the dike parallel to the current is 680 feet long, the total length of the dike, built as above described, being 951 feet.

From the downstream end of the dike the row of piles next the shore was extended 360 feet. A wattling of gum poles, from 3 to 5 inches in diameter, and 20 to 30 feet in length, was applied. The total cost of the dike was:

	Quantity.	Cost per unit.	Total cost.
Rock placed in dike ..... tons..	2,080	$1.29+	$2,686.69
Brush and cane placed in dike ..... cords..	1,045	.618+	645.86
Piles driven in dike ..... number..	201	2.43+	488.86
Piles driven in wattled extension ..... do....	25	2.98	74.57
Poles placed in wattled extension ..... do....	600	.12+	72.54
Piles cut off in dike ..... do....	122	.21	17.08
Hand piles driven in dike ..... do....	76	.21	15.96
Medicine and stationery	.....	.....	29.05
Total	.....	.....	3,930.61

The unit figures in the above table are only approximate. They are obtained by dividing the cost by the quantity in each case.

The shore protection at the root of the dike is 200 feet long, 41.5 feet wide, and 2 feet thick, well staked and wired down and covered with a stone revetment.

As the left bank of the river at this point has been washing greatly for many years, a shore protection was built to stop the erosion. Piles were driven 8 feet between centers along the foot of the bank for a length of 1,110 feet; the bank was cleared of all logs and fallen trees, and sloped where necessary to 45 degrees. Brush, put up in bundles 15 to 20 feet long, was laid shingle-fashion up the slope from five feet, on an average, outside the row of piles to the top of the bank. Stakes were driven through the brush, at intervals of 10 feet, parallel and perpendicular to the bank; No. 10 wire was stretched from stake to stake, three turns being taken about each; the stakes were then driven home. The row of piling was wattled with gum poles and the brush mattress was revetted with stone. The length of bank protected is 1,110 feet, and the mean width is 45 feet. The time required for doing the work was 14 working days.

The cost of this shore protection was:

141 piles, at $2.44 driven	$344.59
350 cords brush, at $0.717	250.90
5,523 square yards mattress made, at $0.026	147.15
672 tons stone, at $1.54	1,035.04
1,200 poles wattled, at $0.121	145.20
Stationery	25.10
Traveling expenses	18.30
Medicine	7.90
Transportation of funds	5.60
Total	1,979.78

The unit figures in the above table of cost are only approximate; they are obtained by dividing the cost by the quantity in each case.

While work was going on at Tate Shoals, another working party replaced the stone which had been dragged off by rafts and drift from the dike at Aberdeen Bar 160 feet, from Dike No. 1 at Carter Shoals 445 feet, and from Dike No. 2 at same place 170 feet.

In making these repairs the cost was:

	Cost.	Total cost.
211 tons stone, costing per ton	$1.426	$300.85
115 piles cut off, costing each	.084	9.65
Total	.....	310.50

When the work at Tate Shoals was finished, the working parties went to Tate Landing, about half a mile below Dike No. 2 at Silver Creek Shoals, to build a short spur dike. A certain amount of material was collected, when the work had to be suspended on account of lack of funds.

The material delivered cost:

	Cost.	Total cost.
50 piles, costing each	$1.336	$66.80
120 cords brush, costing do	.892	107.05
142 tons rock, costing do	1.461	208.96
Total	.....	382.81

SURVEY OF ALABAMA RIVER.

The survey was begun at Kings Landing, July 22, 1895, at a point 102 miles below Montgomery, as nearly as could be determined from the only map of the Alabama River in this office. The survey was continued to Elm Bluff, a distance of 14.4 miles, where it had to be abandoned on account of the appropriation for the improvement of the river becoming exhausted.

Milestones were set up at about every mile. These stones are set at the nearest triangulation point, consequently they do not give exact mileage distances. They are reference points for triangulation and levels, being of more importance as permanent bench marks than as distance posts.

The stones are divided into three parts—the base, the post proper, and the cap. The base is of concrete, made of one part of cement, two of sand, and four of pebbles taken from the bars; it is 24 inches square and 4 inches deep; it is laid on the bottom of the hole in which the post is set. The stone proper is a truncated pyramid 18 inches high, 12 inches square at the lower base, and 6 inches square at the upper. It is of concrete, of the same proportions as the base. It was made in a mold and was allowed to harden before being placed. The cap is a 6-inch cube made of one part sand to one of cement. On top of it is a cast-iron plate 6 inches square and 1 inch thick. On the under side of the plate is cast a lug 2 inches long, 2 inches square at the lower end, and 1 inch square at the neck. It has this shape to prevent the plate being taken off the stone. On top of the plate is a hemispherical nipple 1 inch in diameter with a hole in the top one thirty-second of an inch in diameter to mark the triangulation point. On one side of the nipple the letters U. S. are cast in the plate, and on the other side appears the number of the post.

Milestone 102 is the north end of the initial base line of the survey. The base line is 1,000.09 feet in length. Pegs with smoothly sawed tops 3 or 4 inches in diameter were driven 10 feet apart and leveled accurately. The steel tape, with which the base was measured, was laid out on the pegs and stretched with a pull of 20 pounds. The temperature was taken at the beginning and end of each measurement. The length of the base was measured five times and the average was taken.

A true meridian was laid off at milestone 102. It was obtained by a number of observations on Polaris at its eastern elongation. A concrete block was set up at a point 500 feet south of the milestone. It is of the same shape as the stone. It has no iron plate. The intersection of the two diagonal lines on top of the cubical cap is a point of the N.–S. line through milestone 102. The magnetic variation at milestone 102 is 3° 16′ E.

A second base was measured at milestone 112, on the west bank of the river. Its length was measured as in the case of the first base. It is 848.879 feet.

A meridian was laid off northwardly from the upstream end of the second base. The second stone is on the east bank of the river. The variation as found here is 3° 17′ E.

Whenever it was possible to do so, the survey was carried down the river by a series of quadrilaterals, the angles being measured from points taken on each side of the stream. The cutting through the canes, underbrush, and vines which line both sides of the stream at many points caused, necessarily, great delay in the work. At such places the use of quadrilaterals was suspended, and the instruments were set up on one side of the river only. Points were established on

the other side of the river and pointings were taken on them. Angles were measured between all the points in sight. Each angle was read five times, and a mean of the whole five readings was taken. The instruments used were the ordinary surveyor's transit with a horizontal circle reading to minutes by means of a vernier. In no case where it was possible to take the three angles of a triangle did the latter fail to close by more than a minute.

The triangulation was carried to a point 1,285.58 feet beyond milestone 116.

The error in the measured and the computed length of the second base is 2.059 feet, the computed length being 846.82 feet.

A reference line was marked by two concrete posts on the west side of the river just above Mary Taylor Bar. Its computed length is 1,019.84 feet.

The plane of reference for this survey was assumed arbitrarily at 200 feet below the top of the nipple on milestone 102. Levels were run accurately to all the milestones set up. Three readings were taken alternately on the rear and front rods. The mean of the three readings was taken. If any of the three readings varied more than three-thousandths of a foot from the mean another set of three readings was taken. After each reading the target on the leveling rod was displaced at least a foot; it was then replaced under signals from the leveler.

Gauges were placed at the head and foot of every pool. Readings were taken morning and evening until after the low-water season had passed. The zero of each gauge was referred accurately to the datum plane.

Soundings were located as follows: Stations were chained off 200 feet apart at the pools and 50 feet at the shoals, these distances being checked and corrected on the triangulation points. Ranges were laid off at each station at right angles to the chained line. Two poles were set up on the same bank for each range. The soundings were taken by rowing the boat containing the sounding party a little above the range line, down to which it was allowed to drift. When the ranges closed on the sounding man the sounding was taken; it was located by a transit set up at a convenient point, of which the position was known. The vertical wire of the transit was kept on the sounding rod or line. A sounding rod was used up to a depth of 15 feet; for greater depths use was made of a sounding line.

With the means adopted it is possible to reduce all soundings to low water; to obtain the low-water slope of the pools and shoals; to locate contours of the bed of the river with reference to the datum of the levels.

The heavy cutting along the banks and the constant sickness in the party, of which one-fourth to one-half was unable to work during the whole period of the survey, made the work slow and correspondingly expensive.

The cost of the survey was:

Pay roll	$3,913.74
Subsistence	460.87
Material for triangulation stations	57.81
Oars, rowlocks, etc	9.75
Rods, tape lines, sounding lines, etc	56.93
Medicines	13.95
Stationery	69.79
Traveling expenses	15.05
Telegrams and transportation of funds	5.28
Total	4,603.17
Length of river surveyed ..... miles	14.17
Cost of survey per mile	$324.85
The estimated cost per mile was	$350.00

There is no survey of the Alabama River in existence. Such a survey is necessary to the carrying out of any systematic scheme of improvement. It is to be hoped that the work done last year is but the beginning of a complete survey of this stream.

The necessity for a new towboat having been manifest ever since the work was begun on an extensive scale, which included works of contraction and regularization as well as snagging, the Chief of Engineers authorized September 4, 1895, the purchase of a new towboat at a cost of $15,000. An excellent vessel was found at Pittsburg, Pa., which the owner agreed to deliver fully equipped at Louisville, Ky., for the price named. The name of the boat is *John Mills*. Its dimensions are: Length, 134.5 feet; width, 26 feet; depth of hold, 4 feet; draft of water, loaded, 27 inches. The boat is a stern-wheeler of the model generally used on the Ohio River for small towboats. The wheel is 17 feet 7 inches long, 18 feet in diameter, with 14 buckets $2\frac{1}{2}$ by 24 inches. It is driven by a pair of compound engines of which the high pressure cylinder is 10 inches in diameter, the low pressure $17\frac{7}{16}$ inches, with a stroke of 5 feet; 3 boilers 36 inches diameter, 20 feet long.

The boat left Louisville September 28, in charge of Mr. W. L. Campbell, chief clerk of the United States engineer office at Montgomery, Ala.; made the trip via the Ohio and Mississippi rivers, the Gulf of Mexico, and Mississippi Sound to Mobile, Ala., where it arrived October 15. The trip was made without accident. The boat was delayed three days just inside the Passes of the Mississippi by bad weather, and had a rough trip from the mouth of Cubits Gap to Mississippi Sound.

The boat is brand new, never having made a trip until it went from Pittsburg to Louisville. Its possession by the Alabama River will set the snag boat *Twining* free to attend thoroughly to its legitimate duties.

The material used in the construction of dikes and shore protection was obtained; the stone at Marshall Bluff, 3 cents per ton being paid for quarry rights; brush and cane were cut on the banks, no charge being made therefor; piles were paid for at 95 cents each delivered on the bank; gum poles were cut and loaded by the crews of the steamboats, the price paid being 1 cent per stump.

All work was done by day's labor.

CONDITION OF IMPROVEMENT JUNE 30, 1896.

The river never reached so low a stage as it did during the autumn of 1895. It was 0.8 feet lower between Montgomery and Selma, and 1.25 feet lower below Selma than ever known before. This must be borne in mind in considering the condition of the work.

The result of the work done at Tates Shoals was a straight channel 300 feet wide and 7 feet deep at extreme low water, an increase in depth of 4.5 feet. Steamboats carrying full cargoes had no trouble or delay during the low-water season of 1895–96; in 1894 they had to lighter their cargoes each way across the shoals, causing a delay of twenty-four to forty-eight hours on each trip.

Steamboats carrying full cargoes ran uninterruptedly between Mobile and Hurricane Bluff (a distance of 204 miles) during the entire year; and during the ten months of the year between Mobile and Montgomery.

So far as snags and overhanging timber are concerned, the river is in good although not perfect condition. Since the construction of auxiliary works was begun in 1892, there has been no chance to clear the river thoroughly of this sort of obstructions, as the snag boat had to be in almost constant use as a towboat.

The contraction works built since 1892 are all in good condition. The improvement of the channel obtained at each point holds; at some places there is noticed a further increase of depth. While much good has followed at the immediate point of application of these works, it is impossible to say what effect has been produced on the bed of the river above and below them. No surveys exist to show what has taken place elsewhere than at the place where the work was done. Local surveys had been made at these points, but, as a rule, they show only the changes which have taken place in the depth of water. The surveys at Shackleford Bar, at Carter Shoals, and at Tates Shoals (see Report of the Chief of Engineers for 1895 between pages 1668 and 1669) are good samples of those made up to the present time; they show that the channel depth has been increased, and that is all. As the depth has been increased it is necessary that material has been moved; but what has become of it?

It is quite as important, nay, it is more important for the engineer to know what has become of this material, and what effects have been produced at other points than it is to know that the depth has been increased. If a current strong enough to scour out a sand or gravel bar is brought to bear on the bar, material must be moved until a new channel is obtained of such dimensions as to reduce the strength of the current to what is unable to set any more of the bar in motion. But the engineer ought to know what to do with this material before he sets it in motion; he should have decided upon some definite place for its deposit where, if it can not be made to assist in the work of improvement, it will do no harm.

A careful and accurate survey is required to acquire this knowledge. Such a survey has been begun, a start having been made in the neighborhood of Mary Taylor, Portland, and Hurricane Bluff bars. It was carried over a length of 14.17 miles of the river. A series of these local surveys connected together by a continuous line of levels will give ere long a useful map of the river.

RECOMMENDATIONS AND ESTIMATES.

A small dredge and two dump scows would be a valuable addition to the working plant of the Alabama River. As it is now, when channels are cut through bars by means of contraction works, there is no control over the material which is carried downstream; some of it lands immediately below the place whence it is taken and becomes another bar, which has to be removed in the same manner as the one removed but a short distance above. With dredging, a great deal of material could be carried away and dumped in places where it would do no harm to the channel. In addition to this, there are many cases when a cut could be made through a bar by means of the dredge in less time than it would take to assemble all the materials necessary for the contraction works and for the protection of the bank. A proper dredge for this work would cost about $12,000, and two dump scows would cost about $2,500 each.

It is believed that much good might be accomplished by placing across many of the deep pools of the Alabama River ground sills, of the sort which have worked so successfully on the Rhone and other European rivers, to raise the bottom and thus diminish the depth of water, giving better water in some places over the shoals and in other cases increased currents for cutting away bars. These ground sills would be valuable auxiliaries to the works of contraction which have proved so successful in many cases.

It is estimated that $183,000 can be expended profitably during the fiscal year ending June 30, 1898. This is divided as follows:

Dredging plant	$17,000
Surveys	5,000
Office expenses	6,000
Ordinary repairs	4,000
Extraordinary repairs, which can not be made by the crews employed	15,000
Care of plant	3,000
Two stone barges to replace others worn out	3,000
Expenses of snagging	10,000
Permanent structures	105,000
Dredging	15,000
Total	183,000

The small appropriations given heretofore did not permit of a full utilization of the working plant. The commerce of this stream is large, and so soon as the projected depth of 6 feet shall have been obtained, it is reasonable to suppose that it will become still larger. Its average value for the past six years is $4,800,000 a year.

Money statement.

July 1, 1895, balance unexpended	$34,776.60
Amount appropriated by act of June 3, 1896	40,000.00
	74,776.60
June 30, 1896, amount expended during fiscal year	33,836.29
July 1, 1896, balance unexpended	40,940.31
July 1, 1896, outstanding liabilities	270.93
July 1, 1896, balance available	40,669.38
Amount (estimated) required for completion of existing project	256,251.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	183,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

COMMERCIAL STATISTICS.

The following statement of the business done by the steamboats named below during the fiscal year ending June 30, 1896, has been compiled from statements furnished by Capt. John Quill, of the steamer *Nettie Quill;* by Capt. Clay King, of the steamer *Carrier;* by Capt. T. H. Moore, of the People's Line of steamers, whose steamboats run between Mobile and Montgomery, and by Capt. Phil. Carney, of the steamer *Josie W.*, which runs between Mobile and Selma, and stopping at all intermediate landings, and by the agent of the steamer *Minnie Lee,* a trade boat plying between Mobile and landings in the lower Alabama River:

Stern-wheel steamboats.	Registered tonnage.	Draft.		Round trips.	Passengers carried.	Between—
		Light.	Loaded.			
		Inches.	*Feet.*			
Nettie Quill	226.93	28	6½	40	5,645	Mobile and Montgomery.
Carrier	140.88	24	5½	12		Do.
Tinsie Moore	198.29	24	5½	52	5,672	Do.
Josie W	156.40	24	5½	16	1,701	Mobile and Selma.
Minnie Lee	98	24	5½	Trade boat.		Mobile and Bells Landing.
Alto	363.16	30	7	Laid up.		

Freight carried.

	Quantity.	Equivalent in tons.
Cotton ..... bales..	52,996	13,249
Cotton seed ..... sacks..	75,326	4,431
Fertilizers ..... do....	74,106	7,411
Hides and skins ..... packages..	890	222
Live stock ..... head..	1,905	618
Lumber ..... feet B. M..	227,115	511
Staves ..... pieces..	151,725	1,896
Provisions ..... packages..	190,697	13,348
Grain ..... sacks..	137,267	10,511
Miscellaneous freight ..... packages..	187,697	18,791
Brick ..... number..	40,000	84
Total	.....	71,072

Estimated value of above freight in round numbers, $6,400,000.

In addition to the commerce carried on by the above boats, the rafting business on the river is very large. Very great quantities of sawed and hewed timber, saw logs, lumber, and cord wood are rafted to Mobile annually, but available records of this business are not kept, and no estimate can be made.

O 9.

IMPROVEMENT OF COOSA RIVER, GEORGIA AND ALABAMA.

1. BETWEEN ROME AND EAST TENNESSEE, VIRGINIA AND GEORGIA RAILROAD BRIDGE.

DESCRIPTION AND CONDITION BEFORE IMPROVEMENT.

The Coosa River is formed by the Oostenaula and Etowah rivers, which have their source in the mountains of northern Georgia. The town of Rome, Ga., is situated at their junction. The Etowah is not navigable. The Oostenaula is formed by the junction of the Coosawattee and Conasauga rivers, 60 miles northwest of Rome. The Oostenaula and its larger tributary, the Coosawattee, are navigable for light-draft boats the year round from Rome to Carters Landing, a distance of 105 miles. These rivers have been improved by works of contraction and channel excavation. There would be a continuous water route of transportation from Carters Landing to Mobile, Ala., an estimated distance of 815 miles, but for the shoals and rapids on the Coosa River, distributed over 137 miles from Greensport, Ala., to Wetumpka, Ala. This water route includes the Coosawattee, Oostenaula, Coosa, Alabama, and Mobile rivers.

Prior to 1823 the legislature of the State of Alabama passed "an act to improve the navigation of the Coosa River, and to aid in its connection with the Tenneseee waters." In 1824 this act was formally approved by Congress.

In 1828 Congress provided that any surplus of the grant for improving the Tennessee River should be applied to the improvement of the Coosa, Cahaba, and Black Warrior rivers.

It is not probable that much, if anything, was done under these acts, although steamboats have been plying on the Upper Coosa for some thirty years. (See Report of Chief of Engineers for 1881.)

Between Rome, Ga., and Greensport, Ala., an estimated distance of 173 miles, the river is of such a character as to make its improvement by works of contraction and channel excavation entirely practicable.

From Greensport to Wetumpka, Ala., a distance of 137 miles, the improvement will require the building of locks and dams in conjunction with channel excavation and works of contraction.

PROJECT.

The original project for the improvement of the Coosa River contemplated the opening of a continuous water route of transportation from the Mississippi River to the Atlantic Ocean by way of the Ohio, Tennessee, Coosa, Etowah, Ocmulgee, and Altamaha rivers, with canals from the Tennessee to the Coosa and from the Etowah to the Ocmulgee. This was designated as the "Southern Route." The low-water depth and width of the channel proposed can not be stated from the records at hand.

Various surveys and examinations were made between the years 1870 and 1890 of the part of the Coosa under consideration, i. e., from Rome, Ga., to the Selma, Rome and Dalton Railroad Bridge, now known as the East Tennessee, Virginia and Georgia Railroad Bridge (hereafter in this report the latter designation will be used), an estimated distance of 245 miles. The following list gives the date of each and the estimates based upon them:

1870.—An examination from Greensport, Ala., to the East Tennessee, Virginia and Georgia Railroad Bridge, a distance of 72 miles. Estimated cost of improvement, $417,726.75.

1872.—A survey from Greensport, Ala., to the railroad bridge. No record can be found.

1874.—A survey from Rome, Ga., to the mouth of Wills Creek, 2½ miles below Gadsden, Ala., an estimated distance of 137 miles. Estimated cost of improvement, $180,000.

Summing up.—The total estimated cost of the improvement, determined from the above-described surveys, is as follows:

From Rome, Ga., to the mouth of Wills Creek, in Alabama, an estimated distance of 137 miles	$180,000.00
From Greensport, Ala., to the East Tennessee, Virginia and Georgia Railroad Bridge, an estimated distance of 72 miles	417,726.75
Total	597,726.75

The estimated cost of the improvement from Rome, Ga., to the railroad bridge is given in the Report of the Chief of Engineers for 1877, as follows:

From Rome, Ga., to Wills Creek, in Alabama, an estimated distance of 137 miles	$81,679.00
From Greensport, Ala., to the railroad bridge, an estimated distance of 72 miles	470,668.00
Total	552,347.00

No survey has been made nor has an estimate been submitted for the improvement of that section of the river between Wills Creek and Greensport, Ala., an estimated distance of 36 miles. The only improvement here was made at Leota Reefs, about 1 mile above Greensport.

1890.—A survey from Lock No. 4, situated at the foot of Broken Arrow Shoals, to the East Tennessee, Virginia and Georgia Railroad bridge, a distance of 48 miles. Estimated cost of improvement, exclusive of the cost of Lock No. 4, $945,145.

The contemplated improvement was to be made by works of contraction at the lesser obstructions, and locks and dams at the greater.

The estimates for locks and dams were made for structures, with

crib chamber walls filled with loose stones, and masonry head and tail walls laid in cement. The dimensions of the locks were 200 feet between miter sills and 40 feet wide. Before the building of the locks was begun, the length between miter sills was changed to 210 feet, and it was decided to build masonry structures laid in cement throughout. It was proposed to secure a low-water channel 3 feet deep and 80 feet wide. Below Lock 3 the width and depth was afterwards changed to 100 feet and 4 feet, respectively.

By an act of Congress, approved July 13, 1892, the restrictions as to the size of the locks, imposed by act of Congress approved September 19, 1890, were removed.

Beginning with Lock No. 4, the size of the remaining locks was increased. It is now, length over all, 400 feet; length between miter sills, 322 feet; width, 52 feet; depth over sills, 7 feet.

The channel improvement from Lock No. 4 to the East Tennessee, Virginia and Georgia Railroad Bridge now contemplates a low-water depth of 7 feet and a width of 100 feet.

APPROPRIATIONS.

August 14, 1878	$30,000	August 11, 1888	$60,000
June 18, 1878	75,000	September 19, 1890	150,000
March 3, 1879	45,000	July 13, 1892	130,000
June 14, 1880	75,000	August 17, 1894	110,000
March 5, 1881	60,000	June 3, 1896	50,000
August 2, 1882	83,700		
July 5, 1884	50,000	Total	963,700
August 5, 1886	45,000		

OPERATIONS TO JUNE 30, 1895.

1877.—It is probable that some work was done at Horseleg Shoals, 1½ miles below Rome.

1878.—Work of channel excavation and building wing and training dams was carried on at Horseleg Shoals, Turkeytown Island, Coperas Bluff, Cross Shoals, and Greensport (Leota) Reefs. Approximate quantities were reported as follows:

Rock excavated and removed from channel	cubic yards	1,679
Stone quarried for dams	do	362
Dams built	linear feet	3,893
Snags removed from channel	number	29

1879.—The following quantities were reported for this year:

Rock excavated from the channel	cubic yards	1,333
Stone placed in dams	do	3,100
Stone quarried for dams	do	10,318
Crib and rock dams built	linear feet	1,254
Logs and snags removed from the channel	number	1,286

Average number of men employed, 136.

1880.—*Lock No. 1.*—The laying of masonry was begun, and the permanent dam essentially completed. The channel work between Locks Nos. 1 and 2 was completed except 200 cubic yards of rock excavation at Rock Island Reef.

Lock No. 2.—One thousand one hundred running feet of the permanent dam was built to a height of 3 feet. An earth embankment was carried round the head of the lock to the island below. This embankment is 400 feet long and is to be built above extreme high water. The embankment was one-half finished at the end of the fiscal year.

Quantities were reported as follows:

Solid rock excavated from the channel	cubic yards	1,039
Stone quarried	do	6,124
Stone placed in dams	do	3,714
Timber framed in dams	feet, B. M	5,000
Earth built into embankment	cubic yards	12,000
Stone cut for lock	do	1,178
Rock and gravel excavated from lock pit No. 1	do	3,350
Rubble masonry laid in foundation of Lock No. 2	do	51
Stone broken for concrete Lock No. 2	do	81

One cofferdam 300 by 60 by 8 feet was built.

1881.—Lock No. 1 was finished ready for the gates; the permanent dam was finished excepting a short spur dam to connect with the lock.

Lock No. 2.—The foundation pit was excavated, nine-tenths of the stone was quarried and cut, about one-fourth of the masonry was laid, the foundation of the permanent dam, 1,100 feet in length, was built, two other dams extending below the lock and connecting with Woods Island were well under way when partly destroyed by an unprecedented flood.

Lock No. 3.—A quarry was opened, and quarrying and cutting stone was well under way.

The channel excavation between the head of Whistenant Shoals and Lock No. 2 was finished.

Quantities were reported as follows:

Masonry laid:		
Cut stone	cubic yards	921
Rubble	do	3,291
Stone quarried	do	614
Stone cut for lock	do	748
Solid rock excavation from channel and lock-pits	do	1,945
Loose rock, earth, etc., excavated from quarries, lock-pits, etc	do	12,654
Solid rock placed in dams	do	189
Earth embankment built	do	7,040
Earth placed in cofferdams	do	847
Timber hewn for bulkheads, dams, etc	feet, B. M	132,936

The average number of men employed was 140.

1882.—Lock No. 1.—No work was done except strengthening and tightening the permanent dam by placing earth and gravel against the upper face and loose rock against the lower.

Lock No. 2.—Masonry completed except the coping; this is already cut. The permanent dam was built to within 1 foot of its ultimate height. The dams connecting the lower ends of the lock with Woods Island were nearly complete.

Lock No. 3.—The stone was all cut except about 250 cubic yards; the cofferdam was finished.

A detailed survey was made of the river from Lock No. 3 to Broken Arrow Shoals, a distance of 21 miles downstream.

The following quantities were reported:

Masonry laid, cut stone and rubble	cubic yards	3,154
Dimension stone cut	do	610
Stone quarried for locks and dams	do	9,191
Stone placed in dams	do	14,312
Earth and gravel placed in dams and embankments	do	10,898
Rock excavated from the channel and lock pit	do	728
Earth stripped from quarries, etc	do	3,341
Cribbing in dams, 16 feet base, 4 feet high	linear feet	740

1883.—Lock No. 1.—No work was done except building the spur from the lock to the permanent dam, and strengthening the latter. Two thousand five hundred and seventy cubic yards of stone were used in

the work. A drift boom was built to prevent drift accumulating in the canal above Lock No. 1, but before it was placed in position it was carried away by a flood and destroyed.

Lock No. 2.—The lock masonry and permanent dam were finished. The dams and embankments from the lock to Woods Island were about finished.

Lock No. 3.—All the stone required for the lock was cut. The coffer-dam inclosing the lock pit was built, and the foundation for the lock walls excavated.

Channel work was confined to excavating at Harts and Lonnergan reefs.

Quantities were reported as follows:

	Cubic yards.
Stone quarried for locks	1,319
Stone cut for Locks Nos. 2 and 3	473
Masonry laid, cut stone and rubble	339
Dry rubble slope below Dam No. 2	4,689
Stone quarried for riprap and dams	5,894
Stone and gravel placed in riprap dams	18,596
Earth excavated	2,106
Channel excavation, solid rock	359
Channel excavation, loose rock and gravel	1,140

1884.—Lock No. 1.—The gates were built and placed in position.

Lock No. 2.—The excavation in the lock pit was finished and the bank cleared.

Lock No. 3.—No work was done.

The channels at Harts and Lonnergans reefs were excavated.

Quantities were reported as follows:

Stone and gravel placed in riprap dams	cubic yards	634
Channel excavation, solid rock	do	1,169
Channel excavation, gravel, etc	do	474
Clearing out Lock No. 2	do	150
Logs taken from channel	cords	24
Bank cleared at Lock No. 2	yards	200

Average number of men employed, 22.

1885.—Lock No. 1.—No work was done.

Lock No. 2.—The gates were framed.

Lock No. 3.—The permanent dam and the masonry of the lock, except coping, were finished and the gates were framed.

The excavation of a channel through the reefs in this vicinity was finished except about two weeks' work in removing loose rock and cutting overhanging timber above Greensport.

A detailed survey was made for the location of Lock and Dam No. 4; the work of excavating a channel through the rock reefs down to Riverside, the crossing of the Georgia Pacific Railroad, was completed.

Quantities were reported as follows:

Stone quarried	cubic yards	5,077
Stone cut	do	1,286
Stone built into lock masonry	do	4,406
Stone built into dry rubble dams	do	1,922
Channel excavation, solid rock	do	790
Lock-pit excavation, solid rock	do	2,303
Lock-pit excavation, loose rock and gravel	do	3,455
Earth excavated from quarries, abutments, etc	do	9,846
Timber hewn for miter sills	feet, B. M.	10,080
Timber framed for lock gates	do	36,086

1886.—No work was done at Locks Nos. 1, 2, and 3.

Lock No. 4.—All the stone was cut except the coping.

The following quantities were reported:

	Cubic yards.
Earth removed from quarry	266
Stone quarried	794
Stone dressed	261
Stone transported from quarry to river	714
Channel excavation	143

During the month of April, 1886, the Coosa River rose, in the vicinity of this work, to a height of 6½ feet above the highest known water mark up to that time. Very little damage was done to the work beyond the floating off of some of the gate timbers, the greater part of which were recovered, and the dislodging of a small quantity of riprap stone. The total damage was estimated at $1,100.

1887.—Lock No. 1.—Holes were drilled for the miter-sill bolts.

Lock No. 2.—The gates were set up ready to receive the maneuvering machinery, and the holes were drilled for the miter-sill bolts.

Lock No. 3.—The gates were set up ready to receive the maneuvering machinery; the lower miter sill was laid; the coping transported from the quarries at Lock No. 1, and the holes drilled for the miter-sill bolts.

Lock No. 4.—Quarters for employees were erected and preparations for building the permanent dam were begun. At this lock it was necessary to build the permanent dam before beginning the construction of the lock itself, in order that the stone for the lock might be transported by water from the quarries, some 7 miles above.

Quantities were reported as follows:

Stripping quarry, amount of material removed	cubic yards	86
Stone quarried	do	707
Stone cut and dressed	do	46
Stone transported from quarry to work	do	1,139
Masonry laid	do	663.51
Excavation, lock pits, rock, and earth	do	203
Filling behind lock walls	do	1,655
Concreting in miter-sill foundation	do	63
Repairs to cofferdam, material used	do	168
Gravel removed from channel below lock	do	3,270
Holes drilled for bolts, etc	linear feet	389
Stone received for dam	cubic yards	803.59
Lumber received for dam	feet, B. M.	73,677

1888.—No work was done at Locks Nos. 1, 2, and 3.

Lock No. 4.—Operations were confined, by the limited appropriation available, to quarrying stone for Dam No. 4; building the large cofferdam at the head of the lock, and a crib abutment at the western end of the permanent dam.

The maneuvring machinery for lock gates and culvert gates was received from the Manly & Cooper Manufacturing Company, of Philadelphia, Pa. It could not be placed in position for the want of funds.

Quantities were reported as follows:

Stripping quarry, amount of material removed	cubic yards	3,183
Stone quarried	tons	4,179
Excavation, eastern abutment, earth	cubic yards	148
Riprap placed in cofferdam	do	219
Filling crib, western abutment, and western end of dam	do	1,039
Riprap placed on western abutment	do	11
Filling around western abutment, earth	do	452
Filling cofferdam, clay and gravel	do	1,337
Stone transported to western abutment	tons	594
Holes drilled for bolts, etc	linear feet	384
Stone received for dam, including that quarried	tons	10,852
Lumber received for dam	feet, B. M.	170,208

1889.—The gates and the culvert machinery were erected at Locks Nos. 1, 2, and 3. These three locks were then ready to be opened to navigation except for some alterations required in the culvert valves.

Lock No. 2.—The masonry of the arched culvert was nearly finished. This culvert has an opening 3 feet deep and 15 feet wide and extends the entire length of the lock behind the land wall. It is covered by a rubble arch of 15 feet span, 5 feet rise, and 21 inches depth of keystone.

Lock No. 3.—The cofferdam was removed and the grading of the Government road from the lock to the public road was nearly finished.

The delay in opening Locks Nos. 1, 2, and 3 was due to the fact the Caméré rolling curtain valves which were to be used for filling Locks Nos. 1, 2, and 3, and emptying Lock No. 3, had not worked satisfactorily.

Lock No. 4.—A topographical survey was made of the site of this lock, and current velocity observations taken upon which to base computations for determining the maximum overfall on the dam. A survey of the river from Lock No. 4 to Wetumpka, Ala., was begun.

The following quantities were reported:

Excavation:		
Earth and gravel	cubic yards	8,583
Loose rock	do	306
Solid rock	do	90
Masonry laid	do	1,610
Concrete laid	do	20
Riprap laid	do	188
Stone quarried	do	2,105
Stone transported	do	1,200
Stone cut	do	29
Sand transported	do	269
Drift removed	cords	118
Logs and snags removed	number	268
Holes drilled in masonry	linear feet	589
Centering framed and erected	feet, B. M.	25,368

1890.—Lock No. 1.—The Caméré valves not proving satisfactory, were replaced by balanced valves. The yard, which had been badly scoured by the freshet of 1886, was refilled. The Government road was graded; the gates and all iron parts were painted.

Lock No. 2.—The arched culvert and 50 feet of open conduit below the culvert were completed and the arch filled over with earth. The Government road from the reservation to the county road was graded; the gates and iron parts were painted.

Lock No. 3.—The yard was graded, the gates and iron parts painted, the emptying and filling culvert valves and their protecting gratings were put in position, and the lock was ready to open to navigation.

Lock No. 4.—No work done.

Channel work.—The river was cleared of obstructions between Locks Nos. 1 and 2. The canal between Locks Nos. 2 and 3 was excavated to the level of the lower miter sill at Lock No. 2 and to a bottom width of 80 feet.

1891.—Lock No. 1.—Two levees, each with a top width of 8 feet and an elevation above the lock coping of 10 feet and side and end slopes of 1 on 2, were built and heavily paved around the ends. The yard was paved the entire length of the lock and for a distance of 80 feet back from the lock wall. Two timber guide piers filled with broken stone were built, one at the head and the other at the foot of the lock. A lock keeper's dwelling was built. A part of the stone required at Locks and Dams Nos. 2 and 3 and all that required at No. 1 was quarried at this lock.

Lock No. 2.—A timber guide pier filled with broken stone was built at the foot of the lock. Part of the stone required at Locks Nos. 2 and 3 was quarried here. A lock keeper's dwelling was built.

Lock No. 3.—A timber guide pier at the head of the lock was completed. The yard was graded and paved. A levee extending the entire length of the lock was built and paved where subject to scour. A timber guide pier to be placed at the foot of the lock was framed. A lock keeper's dwelling was built. The work of strengthening the dam and abutment was well advanced toward completion.

Lock No. 4.—All work at this lock had been suspended since the fall of 1888, except that of making surveys and taking velocity observations. A tramroad 1.9 miles long was graded from the site of the lock to the quarry and the ties and rails laid. A Lidgerwood cable way for filling the dam and conveying stone to the western abutment of the dam was built.

Channel work.—After the opening of Lock No. 3 to navigation a steamboat passed through Lonnergan Reef and returned, but found the cross current so strong that all attempts to pass below those reefs were abandoned. During the low-water season of 1890 these reefs were carefully resurveyed, and from this a relocation of the channel was made with its axis parallel to the direction of the current. The channel work was concentrated at this point.

1892.—Lock No. 3.—The work of strengthening the dam and abutment was finished. The lower guide pier was built. At the foot of Woods Island (the entrance to the Ten Islands Shoals Canal) a rough stone dam 222.5 feet long was built parallel to the channel in order to cut off the current which at this point swept across the channel.

The cost of strengthening Dam No. 3, finished, was $7,779.19.

Lock No. 4.—The dam was nearly finished. The western abutment was finished except the coping. That part of the cofferdam lying above the permanent dam was finished. An earth embankment or levee was built on the shore from the western abutment to the high ground. Its crest is 6 feet above the highest known flood. The lock keeper's house was finished, at a cost of $3,149.19.

Channel work.—The cost of rock excavation at Lonnergan Reef was for 1,096 cubic yards at $3.56½ per cubic yard, $3,907.24.

Work was commenced on the cut through the rock reefs at Box Shoals, situated just at the head of the pool of Dam No. 4.

1893.—Lock No. 4.—The work was as follows: Completing the cofferdam, attempting to stop the leaks that had developed in the lock pit, cutting stone for the masonry of the lock walls (it is reported in 1886 that all the stone for this lock except the coping had been cut; the increase in the size of the lock necessitated the cutting of more stone), protecting the bank below the western abutment with a revetment of stone, and completing main dam at total cost of $34,993.12.

Channel work.—The channel at Box Shoals was partly finished so that boats could pass through. Some work was done at three other shoals between Locks Nos. 3 and 4.

No accurate cost of any work done up to this time had ever been kept.

The cost of the work for the year was as follows:

Channel work between Locks Nos. 3 and 4	$10,259.17
Cofferdam for Lock No. 4, including stopping leaks	15,279.63
Quarrying and cutting stone and transportation of stone already cut	25,882.04
Other work of preparation for masonry of Lock No. 4	6,010.84
Coping of west abutment and shore protection below it	857.01
Completing and repairing Dam No. 4	2,807.85
Addition to plant	12,466.15

Repairs, operating, and maintenance of towboat	$6,041.34
Office expenses, superintendence, and items not specially chargeable to any work	9,543.96
Expenses Montgomery office	1,185.00
Recording gauge at Lock No. 5	60.00
Material on hand and unfinished cut stone	236.60
Sundry small amounts belonging to works of previous years	291.74
Total	90,921.33

1894.—Lock No. 4.—The work was as follows: Building cofferdam and stopping leaks; quarrying and cutting stone for masonry of lock walls; repairs to permanent dam; laying abutment and shore protection below it (the total cost of this work complete was $23,372.91); preparing foundation and laying lock masonry, and building dock for repairing steamer and barges.

Channel work.—At Box Shoals the channel was deepened by blasting and dredging. At McCoy Island a channel was partly blasted and dredged. Boats can now pass through. At Woods Reef a channel was dredged through the gravel bar; a channel was partly blasted and dredged at Alligator Reefs. Channels were blasted, but not dredged, at Hunnicut Reefs, Formby Reefs, and Williams Reefs.

The cost of the work for the year was as follows:

Channel work between Locks Nos. 3 and 4	$8,029.71
Cofferdam, Lock No. 4	1,421.01
Quarrying and cutting stone	2,708.78
Construction of Lock No. 4	10,666.65
Other work of preparation for masonry of Lock No. 4	1,599.95
Repairs to Dam No. 4	1,939.80
Maintenance and operating towboat	2,942.01
Laying coping and shore protection, west abutment	656.23
Repairs to buildings	249.04
Expenses Montgomery office	915.00
Addition to plant and material on hand	1,660.77
Repairs to barges	81.13
Engineering and superintendence	5,866.20
Traveling expenses and transportation of funds	252.61
Recording gauge at Lock No. 5	60.00
Building dry dock	585.22
Total	39,634.11

1895.—Lock No. 4.—Authority was granted by letter from the Chief of Engineers, dated December 12, 1893, to build a concrete floor under the lock on account of the bad foundation. The work during the year was confined to preparation for laying this floor and stopping leaks which had developed under the permanent dam after it was finished.

Channel work was continued at Box Shoals, McCoy Island, Woods and Alligator reefs. A force was put to work clearing the channel between Rome, Ga., and Gadsden, Ala., of obstructions which had accumulated since the work on that section of the river was discontinued.

The cost of this work was as follows:

Material on hand (unexpended)		$8,929.79
Addition to plant		10,724.94
Recording gauge and survey at Lock No. 5		179.75
Expenses, traveling and transportation of funds		449.07
Channel work:		
Box Shoals	$2,412.24	
McCoy Island	800.46	
Alligator Reefs	3,072.01	
Fomby Reef	38.00	
Woods Reef	127.60	
Horseleg Shoals and reefs below	1,696.38	
		8,146.69

Repairs to buildings		$3,488.31
Cofferdam:		
Stock ramming	$912.58	
Repairs	153.52	
		1,066.10
Lock No. 4, concrete floor:		
Excavating	3,569.93	
Pumping	1,789.89	
		5,359.82
Dam No. 4, repairs		804.49
Maintenance and operating towboat		2,247.07
Engineering and superintendence		10,328.54
Montgomery office expenses		1,411.35
Repairs to steamer and barges		5,540.88
Transferring stone		86.53
Transporting and setting boilers		854.16
Building dry dock		55.97
Transverse wall		1,102.32
Crushing and delivering stone		2,235.57
Fitting sand screen, screening, and delivering		326.96
Concrete plant:		
Excavation foundation cement house	$480.75	
Building cement house	1,037.53	
Building incline, Lock No. 4	1,578.07	
Crushing plant, Collins Spring	2,736.08	
		5,832.43
Other works of preparation for laying concrete floor		2,798.63
Quarrying stone for concrete floor		4,136.35
Care and preservation of property		125.00
Total		76,230.72

CONDITION OF IMPROVEMENT JUNE 30, 1895.

From Rome, Ga., to Greensport, Ala., many bars are formed, snags and drift have collected in the channel, overhanging trees have grown out from the banks, and it is with great difficulty that boats drawing 2 feet can navigate this section during low water.

Below Greensport the navigation over the improved section is as good as when first opened, there being generally 3 feet in the channel at low water.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1896.

Active operations were suspended on June 30, 1895, on account of the near exhaustion of the appropriation. During the fiscal year the following expenditures were made:

Disbursements July 1, 1895, to June 30, 1896	$34,404.89	
Less obligations July 1, 1895	5,005.36	
		$29,399.53
Material on hand, unexpended, July 1, 1895		8,929.79
Outstanding liabilities June 30, 1895 (unpaid labor)		1,401.18
Total		39,730.50
Expenditures:		
Unexpended material and addition to plant		27,500.19
Building platform for storing cement		240.83
Repairs to main dam, No. 4		183.91
Repairs to towboat		131.60
Machinery for dredge		3,600.00
General repairs to tools and items not chargeable to any special work		715.70
Care and preservation of property		2,126.00
Testing cement		505.15
Expense account, traveling and transportation of funds		206.29
Engineering and superintendence		3,294.16
Montgomery office expenses		1,166.67
Recording gauge at Lock No. 5		60.00
Total		39,730.50

RECOMMENDATIONS AND ESTIMATES.

The cofferdam at Lock No. 4 is becoming more and more insecure each year, and unless funds sufficient to finish the lock within the next two years are appropriated this expensive structure will probably have to be rebuilt. It cost originally $16,500; to rebuild it will cost at least $5,000 more, as the old one will have to be taken out.

During the fiscal year ending June 30, 1898, $218,500 can be profitably expended, as follows:

In the construction of Lock No. 4		$175,000
Purchase of ground for No. 5		1,600
Dredging and blasting channel between Locks 3 and 4:		
Box Shoals	$13,475	
McCoy Island Shoals	1,000	
Alligator Reefs	6,222	
Formby Reefs	1,500	
Hunnicutt Reefs	2,000	
Whiteside Bar	2,500	
Lonnergan Reef	4,000	
		30,697
Channel work between Locks 4 and 5		11,100
		218,397

Money statement.

July 1, 1895, balance unexpended	$41,710.57
Amount appropriated by act of June 3, 1896	50,000.00
	91,710.57
June 30, 1896, amount expended during fiscal year	34,404.89
July 1, 1896, balance unexpended	57,305.68
July 1, 1896, outstanding liabilities	1,406.18
July 1, 1896, balance available	55,899.50
Amount (estimated) required for completion of existing project	800,133.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	218,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

The following commercial statistics are reported by the White Star Line Steamboat Company and the Lathrop-Hatten Lumber Company:

Stern-wheel steamboats.	Registered tonnage.	Draft.		Passengers carried.	Round trips between—
		Light.	Loaded.		
		Inches.	*Inches.*		
Clifford B. Seay	115.80	19	52	2,650	24 Rome and Gadsden, Greensport and Locks 1, 2, and 3.
Resaca	81.00	.....	.....	1,820	92 Rome and Gadsden, Greensport and Locks 1, 2, and 3.
Tony	48.00	.....	.....	.....	10 Rome and Carters Landing.

Freight carried.

rticles.	Quantity.	Tons.
Cotton ..... bales..	14,000	3,150
Cotton seed ..... sacks..	11,000	550
Fertilizer ..... do....	28,000	2,800
Hides and skins ..... packages..	100	5
Live stock ..... head..	100	40
Lumber ..... feet, B. M..	4,000,000	12,000
Timber, rafted in logs ..... do....	6,000,000	54,000
Staves ..... pieces..	250,000	1,100
Provisions ..... packages	30,000	1,600
Grain ..... sacks..	60,000	3,500
Miscellaneous freight ..... packages..	65,000	7,800
Total	.....	86,545

Estimated value of above freights in round numbers, $1,600,000.

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2. BETWEEN WETUMPKA AND EAST TENNESSEE, VIRGINIA AND GEORGIA RAILROAD BRIDGE.—DESCRIPTION AND CONDITION BEFORE IMPROVEMENT.

The original condition of the part of the Coosa River between the East Tennessee, Virginia and Georgia Railroad Bridge and Wetumpka, Ala., was such as to make navigation entirely impossible. The channel way was formed of a series of short, deep pools, seldom more than a mile in length, separated from each other by wide shoals, some of which are as much as 12½ miles in length.

There was no navigation existing on the river, neither had there ever been any, unless floating cotton down the river on flatboats which never returned can be called navigation. These flatboats used to go down the river to Mobile at high water. Since the construction of railways which are able to move the cotton crop to different sea ports this part of the river has never been used.

During the summer and fall of 1889 a hurried survey was made of the part of the Coosa River lying between Lock 4 and Wetumpka, Ala. As a result of this survey, the following project was prepared: To construct 27 locks and dams of varying lifts, to have a uniform available length of 280 feet and width of 52 feet between No. 4 and Wetumpka, the last one of the series, No. 31, being at the last named place. No lift of lock was to exceed 15 feet. In addition to these locks and dams the channel was to be cleared of various rock reefs and points. The depth of water proposed was 4 feet, so far as the channel work was concerned, and 6 feet for the locks. The total estimated cost of the work was $6,074,913.

The river and harbor act of 1890 reduced the length of the proposed locks to 210 feet between hollow quoins and the width to 40 feet. The project was modified on this basis and the total cost placed at $6,038,219.

APPROPRIATIONS.

September 19, 1890	$150,000
July 13, 1892	100,000
August 17, 1894	110,000
June 3, 1896	50,000
Total	410,000

OPERATIONS TO JUNE 30, 1895.

1891.—Operations were begun on November 4, 1891. They were confined to making a detailed survey of the site of Lock No. 31, at Wetumpka, Ala., in gauging the stream, and locating the exact position of the lock to be built.

1892.—Detailed surveys were made of sites for the location of Locks Nos. 29 and 30; a road was graded to the site of the channel work to be done about three-fourths of a mile above Lock No. 31; filling and grading the lock yard at No. 31; rock excavation in the channel; temporary breakwater to protect the cofferdam; construction of workshops, stables, sheds, lock keeper's house, and the various preliminary and incidental preparations for carrying on the work.

1893.—The lock keeper's house, to be used as office and quarters for the engineering force, was finished. The cofferdam was begun in August, 1892. Of the total length of the cofferdam, 900 feet, 322 feet was built during the year. Rock excavation in the channel above the dam was continued. Additions to the plant were made, and everything put in readiness to carry on the work as rapidly as might be.

1894.—The cofferdam was finished November 14, 1893. In attempting to pump out the cofferdam many leaks were found. This was unavoidable, owing to the nature of the site. The ground on which the cofferdam stands is composed of rock, in which the planes of stratification stand at an angle of about 45° with the horizon. The surface of the rock is much broken up, and it is full of fissures. The utmost care was taken in the construction of the cofferdam, but it was found to be practically impossible to fit the sheathing piles to the bottom in such a way as to make a tight joint. Furthermore, the only material for filling the cofferdam to be found was pure clay. This filling, when it becomes dry, cracks open, and so soon as the river rises water immediately begins to flow in through the cracks before the mass on either side swells sufficiently to close them. The water coming through washes with it more or less material, which widens the crack and gives opportunity for more water to follow. Much time was lost during the season in tightening the cofferdam, but it was one of those losses which have to be encountered, and which can not be helped under the conditions.

Work was commenced in the lock pit on May 22, 1894, and about 4,000 cubic yards of sand and loose material were removed, and about 1,000 cubic yards of solid rock excavated and piled behind the land wall.

Rock excavation in the channel above the lock amounted to 14,500 cubic yards. The best of this was broken up by the stone crusher for use in the concrete of the lock walls, the poorer parts being reserved for riprapping, protecting banks, weighting down cofferdam, and for dry filling behind the land wall of the lock.

1895.—Conditions for carrying on the work were very unfavorable during this year on account of excessive amount of high water. The actual working time during which operations could be carried on inside of the cofferdam was only ninety days. The most important work was the partial construction of the concrete lock walls; the walls of the lock chamber and the lower gateway and wing wall were built up to a height of 10 feet 9 inches above the lower sill, about 7,500 cubic yards of concrete being laid. The molds of the upper gateway, in which are 12 arched culverts, were completed, and the holding-down bolts of the upper miter sill and for the floor and head bay were all in place when the river rose in December. The concrete was built up in these parts to the general level after high water subsided. The total amount of concrete put in place was 8,710 cubic yards.

It was thought that time might be saved in the construction by using periods of high water for making large blocks of concrete to be used as coping at the end of the work. The experiment was not satisfactory. The concrete put in these blocks cost about double what it did in the lock walls. The work in the channel above the lock was continued. Seventeen thousand two hundred and fifty-one cubic yards was taken out during the year. The use of the best part of this material reduced the cost of broken stone for the concrete to an average of 76 cents per cubic yard.

CONDITION OF IMPROVEMENT JUNE 30, 1895.

All the temporary work was complete; the entire outfit of plant was in first-class order; the concrete work of the walls, of the breast wall and lift wall, and of the upper gate chamber was up to a level 10 feet 9 inches above the low-water sill; materials were on hand for pushing vigorously the remaining concrete work of the lock; 228 concrete blocks for the coping of the walls were finished; the drawings for the steel gates and the ironwork of the lock were well under way. The rock excavation in the channel above the lock was greater than that provided for by the original project. The excess of stone removed was crushed for concrete. This had a double advantage, it widened a bad channel and supplied broken stone at less cost than it could be bought.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1896.

I can not do better than insert here Mr. Firth's report, who has been in local charge of the construction of this lock since it began, as the report is interesting and contains some valuable lessons of practical experience:

Operations during the past fiscal year have been confined to the completion of the lock walls, the filling in of the space behind the land wall, the removal of most of the temporary work, including a large portion of the cofferdam, and the completion, so far as possible, of the rock excavation in the channel above the lock.

The condition of the river throughout the year has been favorable on the whole to the prosecution of the work, the regular winter flood being a very small one and the other floods being comparatively small and of short duration, the highest stage reached by the river being 30.2 feet above low water, on February 10.

The most important work of the season was the completion of the lock walls. The total amount of concrete put in place during the year, exclusive of what was used in the coping, was 10,079 cubic yards, which, together with the 8,710 cubic yards laid during the previous year and 424 cubic yards of coping, makes the total quantity of concrete used 19,213 cubic yards. Of the coping 192 cubic yards was made in blocks during high-water season and laid by means of a derrick, while the remaining 232 cubic yards was cast in place.

The walls were completed up to the under side of the coping by November 14, 1895, and the placing of the coping was carried on by a very small force during the winter months.

The total cost of the concrete work of the walls, exclusive of coping, was as follows:

Cement, 19,844 barrels, at $2.622	$52,135.85
Broken stone, 16,542 cubic yards, at 82.5 cents	13,647.15
Sand, 6,880 cubic yards, at 31.56 cents	2,171.33
Mixing, depositing, and ramming	12,435.12
Molds and staging	9,613.16
Broken-stone bins and crushing platform	1,922.58
Sand bin and incline	2,435.42
Concrete plant, 10 per cent of total cost	352.60
Erection of and repairs to same	823.71
Stone-crushing plant, 10 per cent of total cost	200.88
Sand-pumping plant, 10 per cent of total cost	426.10
Engineering and superintendence	2,018.70
Total	98,182.60

or a cost of $5.22½ per cubic yard.

The cost of the coping cast into blocks and set with derrick was:

Cement	$757.62
Broken stone	95.00
Sand	21.42
Mixing, depositing, and handling blocks	873.60
Molds (material and labor)	326.48
Cost of laying (cement, labor, and superintendence)	732.82
Total	2,806.94

Of this amount the blocks themselves cost $10.80 per cubic yard, and the placing and setting, including cement, cost $3.82, making a total of $14.62 per cubic yard. The heavy cost of setting was due to the fact that the blocks were not quite true on beds or faces, caused by the warping and twisting of the mold boxes when being cast. This greatly increased the labor of setting, especially on the river wall, where both back and front faces of the blocks were exposed.

The cost of the coping cast in place was:

Cement, 181 barrels, at $2.622	$474.58
Broken stone, 152 yards, at 82.5 cents	125.40
Sand, 76 yards, at 31.56 cents	23.98
Mixing and depositing	583.96
Engineering and superintendence	178.33
Total	1,386.25

or $5.97 per cubic yard.

The very remarkable difference in cost between the coping cast in place and that cast in separate blocks, subsequently set by a derrick, is easily accounted for. In the first place, a much larger proportion of cement had to be used in the blocks (in order to make them sufficiently strong to bear handling and stacking in piles within a reasonably short time after being made, the size of the block ground being very limited), than was necessary in concrete deposited in place. Again, the blocks being cast singly contained more than three times the area of face, made of richer mortar than an equal-sized block of concrete forming part of a much larger mass, especially in the wide portions of the walls. The construction of a special derrick and lifting grips, the handling and stacking of the blocks after being made, the subsequent transfer of the same to their position on the lock walls, the labor of laying them where only a portable hand derrick could be used, and the cost of the cement used in laying were all heavy charges which do not figure in the other class of coping.

The reason for making blocks at all was because it was thought that considerable time might be saved by making them during high-water season, when work on the lock was suspended, but this has proved to be entirely a mistake, as the setting of the blocks occupied almost as much time as an equivalent bulk cast in place.

The cost of the cut stone used in the construction of the walls was:

Hollow quoins and pintle stones	$5,769.24
Setting same	256.78
Square quoins for external angles of walls, sill coping, and coping round chain shafts, and other openings, 40 cubic yards, at $18.71	748.40
Redressing same	487.27
Total	7,261.69

The back filling behind the land wall was completed during the year at a cost of $8,831.66:

Broken stone filling, 2,777 cubic yards, at 98⅓ cents	$2,730.72
Sand and clay filling, 22,346 cubic yards, at 22½ cents	5,027.85
Superintendence	1,073.09
Total	8,831.66

The removal of the cofferdam was commenced before high water set in in January, but not much was done toward it; work was recommenced on June 9 and continued during the remainder of the fiscal year. The stone and clay filling has been deposited behind the land wall, and the timber, after the removal of drift bolts, etc., has been stacked away in the yard for use in the cofferdam at Lock No. 30.

Only a week's work was needed to complete the rock excavation at the head of the rapids at the site of the lock, when the river rose, December 12, 1895, too high to finish it. The total number of cubic yards taken out was 43,059.

Statement of cost of work during fiscal year.

Cement, 9,963 barrels	$30,369.47
Mixing and depositing concrete	7,806.94
Concrete molds, material and labor	5,633.31
Removing cofferdam and other temporary structures (unfinished)	2,488.83
Filling behind land wall	8,072.55
Coping	1,360.52
Rock excavation in channel, 11,131 cubic yards	6,520.17
Stone crushed, 5,273 cubic yards	2,763.97
Montgomery office expenses	2,525.26
Sand pumped and stored in bin, 6,489 cubic yards	1,990.12
Care of and repairs to plant and tools	2,331.11
Broken stone purchased and hauled to yard, 1,000 cubic yards	1,633.51
Hauling broken stone from crusher	1,052.70
Repairs to locomotive and rolling stock	1,158.11
Gate anchorages	3,269.28
Miscellaneous expenses connected with lock	1,054.68
Excavations for wing walls	619.92
Lining well with brick and flooring pump house with concrete	506.99
Repairing water tank and foundations	149.77
Pumping out lock pit	395.94
Care of property during floods	215.25
Subsistence, forage, and firewood	864.70
Dressing corner and special stones	309.04
Laying hollow quoins	275.97
Mooring posts	222.52
Cement testing	286.42
Plant and tools purchased	329.22
Gauge records	138.11
Blue printing and photo materials	131.44
Riprapping river bank	69.30
New commissary	39.71
Traveling expenses and tolls	62.34
Total	84,647.17

RECOMMENDATIONS AND ESTIMATES.

An improvement of the cost and importance of that proposed for the Coosa River is such that it can be carried on with economy and efficiency only by means of large and steady appropriations. At the rate at which appropriations have been given for this river up to the present time, it will take more than one hundred and fifty years to finish the work on the approved project, which will have become antiquated long before that time, judging by the rate at which improvements have been made in transportation facilities during the last few years.

If no improvement is to be made in the present rate of work, it will be much better to abandon the improvement, and I do not hesitate to recommend that it be abandoned. If it is to be continued and carried on in the way that work of such magnitude should be carried on—viz, with large and regular appropriations—$1,000,000 could be expended judiciously during the fiscal year ending June 30, 1898.

Money statement.

July 1, 1895, balance unexpended		$101,507.24
Amount appropriated by act of June 3, 1896		50,000.00
		151,507.24
June 30, 1896, amount expended during fiscal year		85,316.00
July 1, 1896, balance unexpended		66,191.24
July 1, 1896, outstanding liabilities		5,502.19
July 1, 1896, balance available		60,689.05
Amount (estimated) required for completion of existing project		4,683,074.00
Amount that can be profitably expended in fiscal year ending June 30, 1898		1,000,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		

REPORT OF BOARD OF ENGINEERS RELATIVE TO MODIFICATION OF PROJECT FOR CONSTRUCTION OF LOCK NO. 4, COOSA RIVER, GEORGIA AND ALABAMA.

UNITED STATES ENGINEER OFFICE,
Nashville, Tenn., August 26, 1896.

GENERAL: The Board of Engineers constituted by Special Orders, No. 21, Headquarters Corps of Engineers, August 3, 1896, met at Nashville on the morning of August 26, 1896.

The Board had before it the papers mentioned in your letter of August 6, 1896, all of which were carefully considered. * * * After going fully into the merits of each case, the Board came unanimously to the following conclusions:

1. In the case of Lock No. 4, Coosa River, that the present excavation for a concrete floor 8 feet thick be filled up for a depth of 5 feet with broken stone, and with gravel if necessary, and that a concrete floor 3 feet thick be laid on the foundation of loose material thus prepared; that through the unexcavated portion of the foundation of the floor such drains be laid as will carry off all water leaking in through the bottom, care being taken to give such directions to the drains as will prevent water coming in from outside whenever the lock shall be pumped out; that a cross wall of concrete be built at least 6 feet downward, from the under side of the concrete floor of the lock, under the head bay, and a similar wall under the tail bay; and that the foundations of the side walls of the lock be at the same depth as the bottoms of the cross walls.

* * * * * * *

Respectfully submitted.

F. A. MAHAN,
Major, Engineers.
W. L. MARSHALL,
Major, Corps of Engineers.
JOHN BIDDLE,
Captain, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

O 10.

OPERATING AND CARE OF CANALS AND OTHER WORKS OF NAVIGATION ON COOSA RIVER, GEORGIA AND ALABAMA.

Locks Nos. 1, 2, and 3 were opened to navigation June 30, 1890, and have been operated continuously without interruption to navigation. In February, 1895, the canal between Locks Nos. 2 and 3 was frozen over for ten days, thus closing the canal to navigation during that period.

The amounts expended to the end of the fiscal year ending June 30, 1895, was 25,761.96.

During the fiscal year ending June 30, 1896, the following expenditures were made:

Lock No. 1:		
Lock keeper's salary, twelve months, at $50 per month	$600.00	
Painting keeper's dwelling	166.10	
General repairs to dwelling	51.96	
		$818.06

Lock No. 2:		
Lock keeper's salary, twelve months, at $50 per month	$600.00	
Painting keeper's dwelling	203.02	
General repairs to dwelling	64.01	
		$867.03
Lock No. 3:		
Lock keeper's salary, twelve months, at $50 per month	600.00	
Painting keeper's dwelling	315.07	
General repairs to dwelling	6.65	
		921.72
Miscellaneous:		
Renewing lock gates at Locks Nos. 2 and 3		1,482.35
Dredging below Locks Nos. 1, 2, and 3		1,090.31
Completing and repairing dredge		1,671.31
Current and contingent expenses:		
Engineering and superintendence	592.09	
Office supplies and stationery	16.62	
Traveling expenses and transportation of funds	20.51	
		629.22
Montgomery office expenses		200.00
Total		7,680.00

Money statement.

July 1, 1895, balance unexpended	$1,152.53
Amount of allotment	7,644.59
	8,797.12
June 30, 1896, amount expended during fiscal year	8,797.12

APPENDIX P.

IMPROVEMENT OF RIVERS AND HARBORS IN WESTERN ALABAMA AND EASTERN MISSISSIPPI, AND OF BOGUE CHITTO, LOUISIANA.

REPORT OF MAJ. WM. T. ROSSELL, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Mobile Harbor, Alabama.
2. Black Warrior River, Alabama, from Tuscaloosa to Daniels Creek.
3. Warrior and Tombigbee rivers, Alabama and Mississippi.
4. Noxubee River, Mississippi.
5. Pascagoula River, Mississippi.
6. Chickasahay River, Mississippi.
7. Leaf River, Mississippi.
8. Pearl River below Jackson, Mississippi.
9. Pearl River between Carthage and Jackson, Mississippi.
10. Pearl River between Edinburg and Carthage, Mississippi.
11. Bogue Chitto, Louisiana.

SURVEYS.

12. Black Warrior River, Alabama, from Daniels Creek to the Mulberry and Locust Fork.
13. Mobile Harbor, Alabama.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., July 20, 1896.

GENERAL: I have the honor to forward herewith annual report * * * for the fiscal year ending June 30, 1896, for the works of rivers and harbors under my charge.

* * * * * *

Very respectfully, your obedient servant,

WM. T. ROSSELL,
Major of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

P 1.

IMPROVEMENT OF HARBOR AT MOBILE, ALABAMA.

The channel leading from Mobile to the deep water in the Gulf of Mexico has been subject to many fluctuations in depth. Among the earliest maps and charts made, I find in this office and submit copies herewith as follows:

1. The Nautilus map, 1764, showing a depth of 15 feet over the outer bar at high water.

2. British admiralty chart, 1771, showing depth of 10 feet over the outer bar and less than 10 feet to the city of Mobile.

3. Mexican map (date unknown) showing less than 18 feet over the outer bar and less than 12 feet to the city.

4. The Curtis Lewis map, 1820, showing less than 16 feet over the outer bar and from 7 to 8 feet to the city.

The last is probably the most accurate of all.

The variation in the depths found over the outer bar is very noticeable, and in Pickett's History of Alabama it is stated that on "February 18, 1702, Iberville found 20 feet over the outer bar."

The history of the outlets from Mississippi Sound as well as from Mobile Bay has been one of change. The present outlet of Mobile Bay has, however, been quite permanent in position, and is at present deepening. The Coast Survey chart of 1864 shows this channel in practically the same position as now and with a depth of 20 feet. It is possible that in the future, under natural causes, a change may occur. At the present time there is a depth of 24 feet at mean low water.

Up to the present time no work has been necessary on the outer bar, as there has always been more water there than could be carried up to Mobile. It is now, as it always has been, the custom to finish loading vessels, where draft is too great to reach Mobile fully loaded, in the deep pocket inside Mobile Point.

On the channel leading to the wharves at Mobile, work was first done by the General Government in 1827, the depth of water then being 5½ feet through Choctaw Pass and 8 feet on Dog River Bar.

The following appropriations were made by Congress:

May 20, 1826	$10,000.00
March 2, 1829	20,000.00
June 24, 1834	10,000.00
March 3, 1835	17,997.60
March 3, 1837	50,000.00
July 7, 1838	50,000.00
August 3, 1852	50,000.00
	207,997.60
March 3, 1857 (relief claim)	20,833.08
Total	226,830.68

The result obtained was a channel 10 feet deep and 200 feet wide through Choctaw Pass and the same depth for an unknown width over Dog River Bar, thus giving an unobstructed channel of 10 feet in depth from Mobile to the Gulf of Mexico.

In 1860 the channel was found to have shoaled to 7½ feet at Choctaw Pass. No further improvement was attempted until 1870 by the General Government. However, in 1869 the legislature of Alabama created a commission for the improvement of the harbor. This commission removed obstructions from the harbor, the funds being provided by bonds of the county of Mobile. This commission also did some dredging on Dog River Bar and built dikes at Pinto Pass, Pinto Point, and Garrows Bend. Their work ceased in March, 1873. A portion of these dikes were afterwards removed, as they were found detrimental.

In 1870 the second stage of the improvement was entered on. The project under which this work was done was submitted by Maj. C. B. Reese, Corps of Engineers, August 5, 1870. It proposed to open a channel 300 feet wide and 13 feet deep by dredging and moving obstructions

from Mobile to the Gulf of Mexico. This project was finished in 1876, under the following appropriations:

By act of Congress—	
July 11, 1870	$50,000
March 3, 1871	50,000
June 10, 1872	75,000
March 3, 1873	100,000
June 23, 1874	100,000
March 3, 1875	26,000
Total	401,000

The amount of material removed was 1,305,911 cubic yards, the price varying from 50 cents to 17 cents per yard.

The river and harbor law of June 18, 1878, appropriated the sum of $10,000 for a survey for a channel permitting vessels drawing 22 feet of water to come to the wharves of Mobile. Under this law Lieut. Col. (then Capt.) A. N. Damrell, submitted two estimates, one for a channel 17 feet deep and 200 feet wide, and the other for a channel 21 feet deep and 200 feet wide, in either case the work to be done by dredging. Colonel Damrell also submitted plans for retaining the improved channel by dikes. However, it was decided to continue dredging to obtain a channel 200 feet wide and 17 feet deep.

In this third stage of the improvement the work was done under appropriations as follows:

June 18, 1878 (survey)	$10,000
March 3, 1879	100,000
June 14, 1880	125,000
March 3, 1881	100,000
August 2, 1882	125,000
July 5, 1884	200,000
August 6, 1886	90,000
Total	750,000

The amount of material excavated was 5,973,854 cubic yards, the price varying from 12.3 cents to 9 cents per cubic yard.

In 1889 this project was practically completed, a vessel passing through the channel drawing 18 feet. Before the completion of this project on February 6, 1885, a project was submitted to obtain a channel 23 feet deep at mean low water.

The estimated cost of this improvement, in which was included finishing the 17-foot project, was $2,043,800 and $60,000 annually for maintenance. The upper end of this channel was also changed from the wharves at Mobile to the mouth of Chickasabogue Creek, a distance of more than 2 miles.

The fourth stage of this work was begun under this project in 1888, and has been completed.

Appropriations have been made as follows:

By act of Congress—	
August 11, 1888	$250,000
September 19, 1890	350,000
July 13, 1892	212,500
Sundry civil act, March 3, 1893	500,000
Sundry civil act, August 18, 1894	390,000
Sundry civil act, March 2, 1895	291,300
Total	1,993,800

In the river and harbor law of July 13, 1892, this work was placed under the continuous contract plan. The work was divided into two parts, first from mouth of Chickasabogue Creek to the mouth of the river, and second from the mouth of the river to the deep water near

Fort Morgan. Contracts were let for these two parts separately, as follows:

River part.—Rittenhouse Moore Dredging Company for 16.5 cents per cubic yard, measured in place. Work on this contract began on March 6, 1894, and was finished on July 9, 1895, resulting in removing 334,335.94 cubic yards.

Bay part.—National Dredging Company, of Wilmington, Del., for 7.7 cents per cubic yard, measured in scows. Work began on November 7, 1892, and finished on October 3, 1895, resulting in removing 16,020,150 cubic yards.

After the completion of these contracts there was a channel from the mouth of Chickasabogue Creek to deep water in the Gulf of Mexico with a variable width and depth of 23 feet at mean low water.

The channel has not been permanent, but has filled, particularly below the Middle Bay Light or Station K. Here the channel had shoaled in places to 19 feet; still vessels continued going through drawing more than 23 feet and this on about 1.5-foot tide. This shows that the material of the fill was very soft. An examination shows that it is so light as to be easily moved under the action of waves and we may expect that fills will constantly occur. Another source of deterioration to the channel is its narrowness, vessels strike the banks constantly and cause fills.

The slopes of the banks when formed of this soft material are or will be very flat. Already we find in places a slope of 1 in 20 and foreign experience leads me to believe that it will in time become much flatter.

No work has been done during the fiscal year in removing snags or deadheads from the channel, these occur in quite large numbers and they should be removed at least once a year.

On March 16, 1896, the following joint resolution of Congress became a law by the approval of the President:

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the National Dredging Company, the contractor under the continuing contract for the improvement of the harbor at Mobile, Ala., proceed with the work of dredging, under the direction of the Secretary of War, until the channel under improvement shall be completed to a width of two hundred and eighty feet, payment therefor to be made at the rate specified in said contract, seven and seven-tenths cents per cubic yard, out of appropriations as they shall hereafter from time to time be made: *Provided,* That the payments upon said contract shall be held to be due only after appropriation shall have been made therefor, and shall not exceed in the aggregate the sum limited for said work in the appropriation bill of July thirteenth, eighteen hundred and ninety-two, authorizing a continuing contract for said work.

Under this law work was begun on April 18, 1896, the contractor using two dredges. Up to June 30, 1896, 1,148,294 cubic yards of material have been removed.

I inclose herewith a chart of Mobile Bay, showing the position of the dredged channel and the position of the numbered stations. These stations are half a mile apart. I also inclose a plat * showing the dredging done under the joint resolution. Dredging began at Station No. 42, 21 miles from the mouth of Chickasabogue Creek, and extended to 738 feet south of Station No. 57, being a total distance of 7.63 miles.

The dredges employed were the *Bismarck* and the *Chas. Fobes.* They are both clam-shell dredges, the *Bismarck* having a bucket with a capacity of 10 cubic yards, and the *Chas. Fobes* one of 5 yards. Both dredges worked day and night. The *Bismarck* removed 624,341 cubic yards, being an average of 60,776.55 cubic yards per week and 11,050.28 cubic yards per day of twenty-four hours.

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* Not printed.

The *Chas. Fobes* removed 523,953 cubic yards, being an average of 49,685.19 cubic yards per week, and 9,033.67 cubic yards per day of twenty-four hours.

At the close of the fiscal year there is a channel of variable width and 23 feet deep at mean low water extending from the wharves at Mobile to deep water in the Gulf of Mexico.

During the year a report was made giving estimate for a channel 23 feet deep at mean low water, 100 feet wide at bottom, with proper slopes, published as House Doc. No. 199, Fifty-fourth Congress, first session.

The care of the bay, harbor, and channel is by a State law placed in the care of the harbor master and port wardens.

The total amount expended on this improvement to June 30, 1896, is $1,992,352.79.

Tabular statement showing the channel as dredged and its condition June 30, 1896.

Locality.	Dredged.		Examinations.					
	Width.	Central depth.	Cross section at—	Distance between stations.	Top width.	Maximum depth in cross section.		
						June, 1891.	June, 1895.	June, 1896.
	Feet.	*Feet.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Station 0	.....	.....	Initial point at mouth of Chickasabogue Creek.	.....	1,650	15.9	16.5	15.6
			South of initial point.					
Station 0 to 1	.....	.....	0.50 mile	2,640	950	23.0	28+	24.5
Station 1 to 2	.....	.....	1.00 mile	2,640	750	21.3	24.9	24.3
Station 2 to 3	.....	.....	1.50 miles	2,640	800	21.3	28+	27.8
Station 3 to 4	120	23-24	2.00 miles	2,640	1,060	18.9	26.8	25.1
Station 4 to A	120	23-24	2.03 miles	200	1,070	18.9	26.8	24.8
Station A to 5	120	23-24	2.50 miles	2,440	960	21.3	25.8	24.4
Station 5 to 6	120	23-24	3.00 miles	2,640	1,035	16.7	25.9	24.2
Station 6 to 7	160	23-24	3.50 miles	2,640	910	16.5	24.3	23.4
Station 7 to B	80	23-24	3.54 miles	240	890	17.1	23.8	23.4
Station B to 8	80	23-24	4.00 miles	2,400	720	16.4	23.2	22.3
Station 8 to C	80	23-24	4.21 miles	1,210	700	19.7	24.2	23.5
Station C to 9	80	23-24	4.50 miles	1,430	570+	21.3	25.1	27.7
Station 9 to 10	240	23-24	5.00 miles	2,640	700	19.7	25.1	27.8
Station 10 to D	240	23-24	5.04 miles	245	700	17.6	25.5	26.5
Station D to E	475	23-24	5.35 miles	1,650	700	19.6	28+	27.0
Station E to 11	475	23-24	5.50 miles	745	700	19.9	28+	26.1
Station 11 to F	475	23-24	5.54 miles	233	700	19.9	26.0	26.9
Station F to 12	280	23-24	6.00 miles	2,407	700	21.3	28+	24.8
Station 12 to G	280	23-24	6.38 miles	2,034	700	18.3	28+	27.9
Station G to 13	280	23-24	6.50 miles	606	700	18.8	28+	27.2
Station 13 to 14	280	23-24	7.00 miles	2,640	700	24.5	26.6	24.1
Station 14 to 15	280	23-24	7.50 miles	2,640	700+	24.5	26.9	24.1
Station 15 to 16	280	23-24	8.00 miles	2,640	700+	26.3	28+	25.1
Station 16 to H	280	23-24	8.07 miles	404	700+	26.3	28+	24.5
Station H to I	340	23-24	8.49 miles	2,228	700+	24.8	28+	25.0
Station I to 17	340	23-24	8.50 miles	8	700+	24.8	28+	25.0
Station 17 to 18	280	23-24	9.00 miles	2,640	700+	21.8	28+	25.2
Station 18 to 19	280	23-24	9.50 miles	2,640	700+	25.0	25.8	27.9
Station 19 to 20	280	23-24	10.00 miles	2,640	700+	26.3	28+	25.2
Station 20 to 21	280	23-24	10.50 miles	2,640	700+	16.9	28+	27.6
Station 21 to 22	280	23-24	11.00 miles	2,640	700+	16.7	25.1	24.6
Station 22 to 23	280	23-24	11.50 miles	2,640	700+	16.1	25.5	23.0
Station 23 to 24	280	23-24	12.00 miles	2,640	700+	16.5	25.6	23.0
Station 24 to 25	280	23-24	12.50 miles	2,640	700+	16.4	25.7	24.9
Station 25 to 26	280	23-24	13.00 miles	2,640	700+	16.5	25.5	23.9
Station 26 to 27	280	23-24	13.50 miles	2,640	700+	16.2	28.0	24.3
Station 27 to 28	280	23-24	14.00 miles	2,640	700+	16.9	25.8	25.8
Station 28 to 29	280	23-24	14.50 miles	2,640	700+	16.1	24.4	23.5
Station 29 to 30	280	23-24	15.00 miles	2,640	700+	16.2	28+	24.5
Station 30 to 31	280	23-24	15.50 miles	2,640	700+	16.3	26.2	22.8
Station 31 to 32	280	23-24	16.00 miles	2,640	700+	16.5	26.7	22.9
Station 32 to 33	280	23-24	16.50 miles	2,640	700+	16.1	28+	23.2
Station 33 to 34	280	23-24	17.00 miles	2,640	700+	16.1	28+	23.0

Tabular statement showing the channel as dredged and its condition June 30, 1896—Cont'd.

Locality.	Dredged.		Examinations.					
	Width.	Central depth.	Cross section at—	Distance between stations.	Top width.	Maximum depth in cross section.		
						June, 1891.	June, 1895.	June, 1896.
	Feet.	*Feet*	*South of initial point*—Cont'd.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Station 34 to 35	280	23–24	17.50 miles	2,640	700+	15.5	27.0	23.0
Station 35 to 36	280	23–24	18.00 miles	2,640	700+	15.7	27.7	23.4
Station 36 to 37	280	23–24	18.50 miles	2,640	700+	15.4	26.2	24.3
Station 37 to 38	280	23–24	19.00 miles	2,640	700+	15.5	26.8	23.5
Station 38 to 39	280	23–24	19.50 miles	2,640	700+	15.3	28+	24.5
Station 39 to 40	280	23–24	20.00 miles	2,640	700+	15.4	28+	24.5
Station 40 to J	280	23–24	20.47 miles	2,471	700+	15.0	26.2	24.0
Station J to 41	500	23–24	20.50 miles	169	700+	15.0	25.5	23.2
Station 41 to K	500	23–24	20.63 miles	671	700+	15.0	25.1	23.0
Station K to L	500	23–24	20.80 miles	918	700+	14.6	24.8	22.4
Station L to 42	280	23–24	21.00 miles	1,051	700+	14.6	28+	25.6
Station 42 to 43	280	23–24	21.50 miles	2,640	700+	14.7	26.3	26.0
Station 43 to 44	280	23–24	22.00 miles	2,640	700+	14.3	26.0	26.0
Station 44 to 45	280	23–24	22.50 miles	2,640	700+	18.4	24.5	25.6
Station 45 to 46	280	23–24	23.00 miles	2,640	700+	22.0	25.4	27.4
Station 46 to 47	280	23–24	23.50 miles	2,640	700+	22.8	24.5	24.6
Station 47 to 48	280	23–24	24.00 miles	2,640	700+	21.5	24.5	27.6
Station 48 to 49	280	23–24	24.50 miles	2,640	700+	21.6	25.6	25.3
Station 49 to 50	280	23–24	25.00 miles	2,640	700+	21.5	28+	23.9
Station 50 to 51	280	23–24	25.50 miles	2,640	700+	19.0	28+	24.8
Station 51 to 52	280	23–24	26.00 miles	2,640	700+	18.0	28+	26.0
Station 52 to 53	280	23–24	26.50 miles	2,640	700+	13.0	28+	26.4
Station 53 to 54	280	23–24	27.00 miles	2,640	700+	13.2	25.6	23.6
Station 54 to 55	280	23–24	27.50 miles	2,640	700+	13.7	26.9	26.7
Station 55 to 56	280	23–24	28.00 miles	2,640	700+	13.7	27.1	25.3
Station 56 to 57	280	23–24	28.50 miles	2,640	700+	14.4	28+	23.6
Station 57 to 58	280	23–24	29.00 miles	2,640	700+	14.4	28+	21.9
Station 58 to 59	280	23–24	29.50 miles	2,640	700+	14.4	27.2	21.3
Station 59 to 60	280	23–24	30.00 miles	2,640	700+	15.3	27.5	21.6
Station 60 to 61	280	23–24	30.50 miles	2,640	700+	16.1	27.2	21.3
Station 61 to M	280	23–24	30.81 miles	1,659	700+	16.1	25.7	21.4
Station M to 62	200	23–24	31.00 miles	981	700+	16.2	27.1	22.9
Station 62 to 63	200	23–24	31.50 miles	2,640	700+	23.2	28+	23.9
Station 63 to 64	200	23–24	32.00 miles	2,640	700+	22.3	28+	27.9
Station 64 to 65	200	23–23	32.50 miles	2,640	350	21.0	28+	29.4
Station 65 to 66	200	23–24	33.00 miles	2,640	370	22.9	28+	26.8
Station 66 to N	200	23–24	30.08 miles	459	390	23.1	28+	25.9

To November 7, 1892, dredging operations were regulated by the old tide-gauge referring to a bench mark, which is the horizontal top of the west abutment of the steps of the custom-house, Mobile, Ala., said datum line being 11.81 feet above the zero of that gauge. Since November 7, 1892, the new tide-gauge governing dredging operations refers to the same bench mark, with the difference that the zero of the gauge has been lowered to 13.51 feet below said datum line to agree and conform with the soundings of charts of the United States Coast and Geodetic Survey.

Money statement.

July 1, 1895, balance unexpended	$306,821.16
Amount appropriated by act of June 3, 1896	60,000.00
Amount appropriated by sundry civil act approved June 11, 1896	160,000.00
	526,821.16
June 30, 1896, amount expended during fiscal year	305,373.95
July 1, 1896, balance unexpended	221,447.21
July 1, 1896, amount covered by uncompleted contracts	160,000.00
July 1, 1896, balance available	61,447.21
Amount (estimated) required for maintenance	300,000.00
Amount that can be profitably expended for maintenance in fiscal year ending June 30, 1898	200,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

LETTER OF MR. A. C. DANNER.

MOBILE, ALA., *June 9, 1896.*

Maj. WM. T. ROSSELL,
United States Engineer in charge at Mobile, Ala.

MAJOR: We have learned that you are now engaged in preparing your annual report. It occurs to us that it may be acceptable to you to have in hand such authoritative statistical data (to be selected from in your judgment) as will bear you out in any assertions that it may suit you to make in reference to the success of the work that the Government has been engaged in at Mobile through your predecessor, Major Damrell, and yourself.

Our people appreciate thoroughly the fact that the Government has regard for the harbor and port of Mobile as of national importance, and also appreciate the splendid success of the work which has been carried on up to this time with such conspicuous intelligence. We deem it that we can not be considered "cormorant-like" in nature in giving utterance to some ideas that may be regarded in the light of suggestions. It would seem, however, that the commercial bodies should have a fair comprehension, at least, of the actual needs of commerce; consequently we will proceed to state that although the increase of depth in our channel has materially added to the business of Mobile, as furnished to you in the accompanying statistics, the practical use of the channel emphasizes the fact of its being too narrow, and should be at least three feet deeper, to entirely accommodate the vessels that are now actually applying and coming here. It is of record that several steamships that came here during the past season were unable to take their full cargo in Mobile. At this writing we have in port the British steamship *Laurel Branch*, that can not load her full cargo and her coal bunkers here, as she will draw too much water for the channel. It is also necessary, in order to fully realize the advantages that have been given us in our deeper channel, that the loading basin in front of our city and mills should be dredged out from wharf line to wharf line, where it becomes necessary, to make it as deep as the contiguous channel. This should be done not only in front of the business portion of the city proper, but should extend as well up to the distance of about 1 mile above Chickasabogue Creek, where most of the timber and lumber vessels lie while loading. Within this 1 mile above Chickasabogue there is a deep and wide basin, but there runs out, quite across the river there, a narrow bar that effectively prevents the use of this basin for loading large vessels, and more loading space is now absolutely necessary.

We understand that money has been appropriated for widening the channel extending down the bay of Mobile, and we trust you will see the fairness of our request to include in your recommendations the further improvement we have asked for, including a cut through the bar just above Chickasabogue Creek, referred to in the foregoing. It has been demonstrated that our improved harbor has already proven of great benefit to the commerce, not only of the State of Alabama, but as well to the commerce of our sister States of Mississippi, Tennessee, Kentucky, Mississippi, Kansas, and Illinois, providing another and more convenient seaport to the advantage of interstate commerce.

You will particularly note that Mobile's tonnage movement for a period of nine years shows an increase of 458 per cent up to September 1, ultimo and every month during the current year shows a steady and continuous increase of use for the channel.

The imports and exports for the nine months ending March 31, 1896, compare for a period of three years, as follows:

	1894.	1895.	1896.
Imports	$362,744	$628,790	$583,502
Exports	2,295,823	4,160,656	5,768,619
Total	2,658,567	4,789,446	6,352,121

	Per cent.
Increase over 1894	140
Increase over 1895	32.6

We would remark that business with the West Indies and Central America, as shown by the accompanying statistics, is entirely new in character, and we are supplanting some goods that have heretofore been shipped from England. The export of Alabama iron from this port at least has been engaged in for the first time during the past season, not only to England and other European ports, but also to the Empire of Japan.

We beg to supplement the statistics already referred to by figures for the month of May just passed, which shows our foreign trade for the past eleven months, demonstrating that our progress has been steadily maintained,

We crave your indulgence for our prolixity, and plead that this matter is of sufficient importance to justify it.

Very respectfully yours, A. C. DANNER, *President.*

Attest: A. POPE ST. JOHN, *Secretary.*

COMMERCIAL STATISTICS.

Comparative statement tabulated from information furnished by the United States custom-house.

Description.	Entries.				Clearances.			
	1896.		1895.		1896.		1895.	
	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.
Foreign	412	290,378	418	239,572	413	295,968	434	254,469
Coastwise	59	41,827	71	44,236	48	21,301	60	25,778
American	36	15,750	52	17,648	33	12,067	54	18,090
Total	507	347,955	541	301,456	494	329,336	548	298,337

Imports and exports.

	1896.	1895.
Duties on imports	$19,215.43	$18,641.63
Tonnage tax	11,701.76	8,402.10
Care and treatment of foreign seamen and overtime of officers	1,154.50	931.50
Official fees	2,829.54	3,114.61
Fines, penalties, storage, etc	152.71	266.40
Total	35,053.94	31,356.24
Exports:		
Domestic	6,985,876.00	5,111,716.00
Foreign	10,203.00	611,317.00
Total	6,996,079.00	5,723,033.00

Comparative statement of lumber, cotton, etc., shipped to foreign and coastwise ports.

Description.	1896.	1895.	1894.	1892.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Lumber	88,045	83,557	107,246	76,055
Timber	129,021	144,737	60,468	73,527
Shingles	185	825	2,259	1,350
Cotton	52,090	29,941	9,835	.....

Comparative statement of number and draft of vessels passing up and down the dredged channel during the fiscal year ending June 30, 1896.

Draft in feet.	Steamships.				Square-rigged vessels.				Schooners.				Total.			
	Up.		Down.		Up.		Down.		Up.		Down.		Up.		Down.	
	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.	1896.	1895.
Under 13	253	271	131	182	98	51	8	2	7	135	.....	90	358	457	139	274
13 to 14	16	18	32	17	30	24	1	3	94	.....	30	2	140	42	63	22
14 to 15	16	29	16	50	30	22	5	9	.....	.....	39	10	46	51	60	69
15 to 16	12	8	24	19	15	13	12	6	.....	4	20	15	27	25	56	40
16 to 17	11	13	20	42	5	4	15	6	.....	2	5	17	16	19	40	65
17 to 18	1	.....	16	7	1	1	15	6	.....	.....	.....	2	2	1	31	15
18 to 19	.....	.....	38	7	.....	1	20	5	.....	.....	.....	2	.....	1	58	14
19 to 20	.....	1	5	1	2	.....	11	16	.....	.....	.....	.....	2	1	16	17
20 to 21	.....	.....	3	4	.....	.....	23	17	.....	.....	.....	.....	.....	.....	26	21
21 to 22	.....	.....	6	4	.....	.....	13	10	.....	.....	.....	.....	.....	.....	19	14
22 to 23	.....	.....	9	3	.....	.....	34	24	.....	.....	.....	.....	.....	.....	43	27
23 to 23.7	.....	.....	3	.....	.....	.....	19	6	.....	.....	.....	.....	.....	.....	22	.....
Total	309	340	303	336	181	116	176	110	101	141	94	138	591	597	573	584

MOBILE BAY

DAUPHINE ISLAND

Guillori Island

the East Point

Pelican Island
with Small Scruby Bushes

10 Feet

5 Feet

Point of Mobile Bold & Steep
appearing like a Bluff

12 Feet

the Bar
15 Feet at High water
Steep

A DRAUGHT
of the
ENTRANCE of MOBILE.

Taken in the King's Ship Nautilus *in the Year 1764.*

Six Miles or Two Leagues.

1 2

To accompany Report for Fiscal Year
ending June 30th 1896.

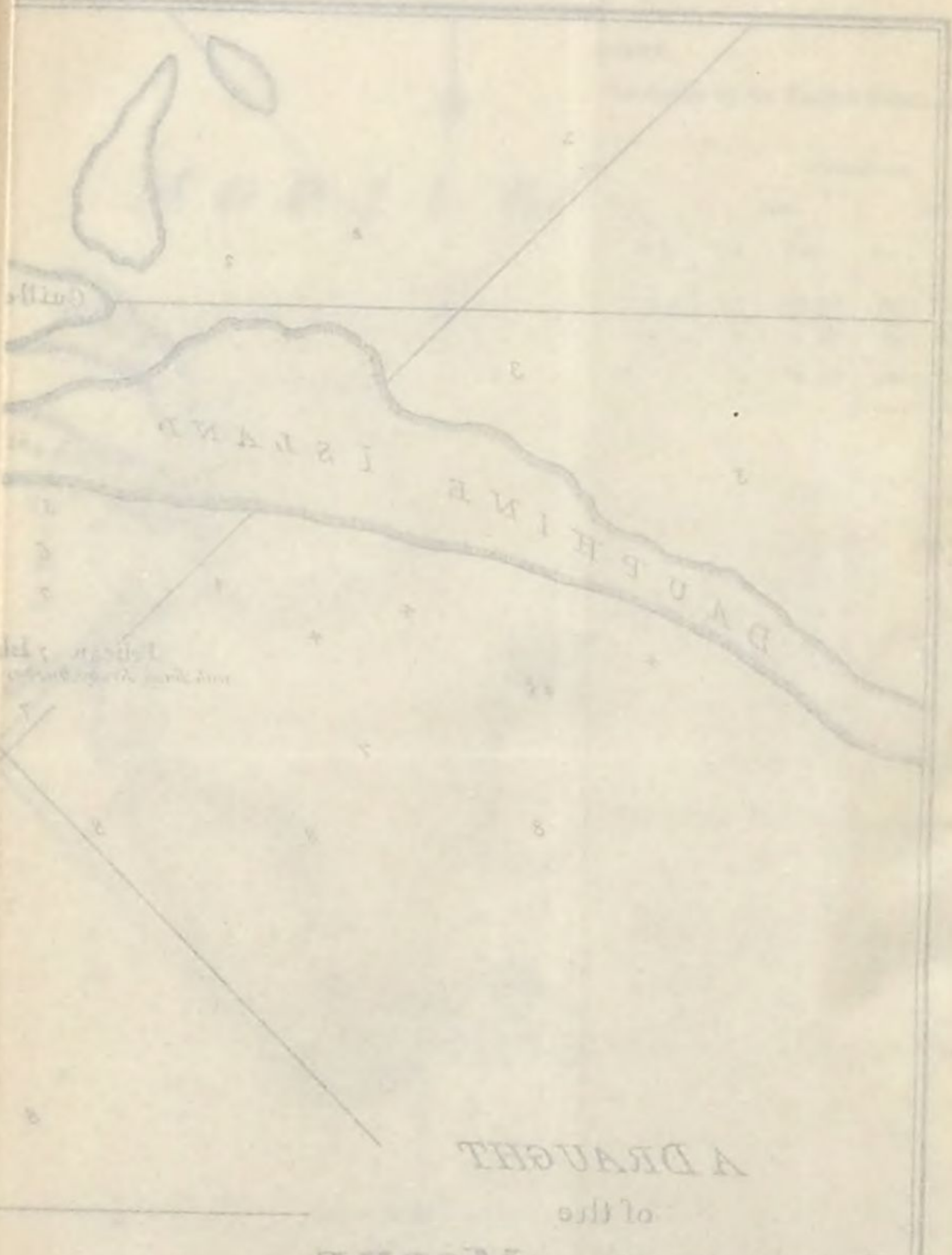
Major of Engineers, U.S.A.

ANDREW B GRAHAM PHOTO LITHO WASHINGTON D.C.

London Printed for ROBERT SAYER *N°53 Fleet Street as the Act directs Jan. 1st 1788.*

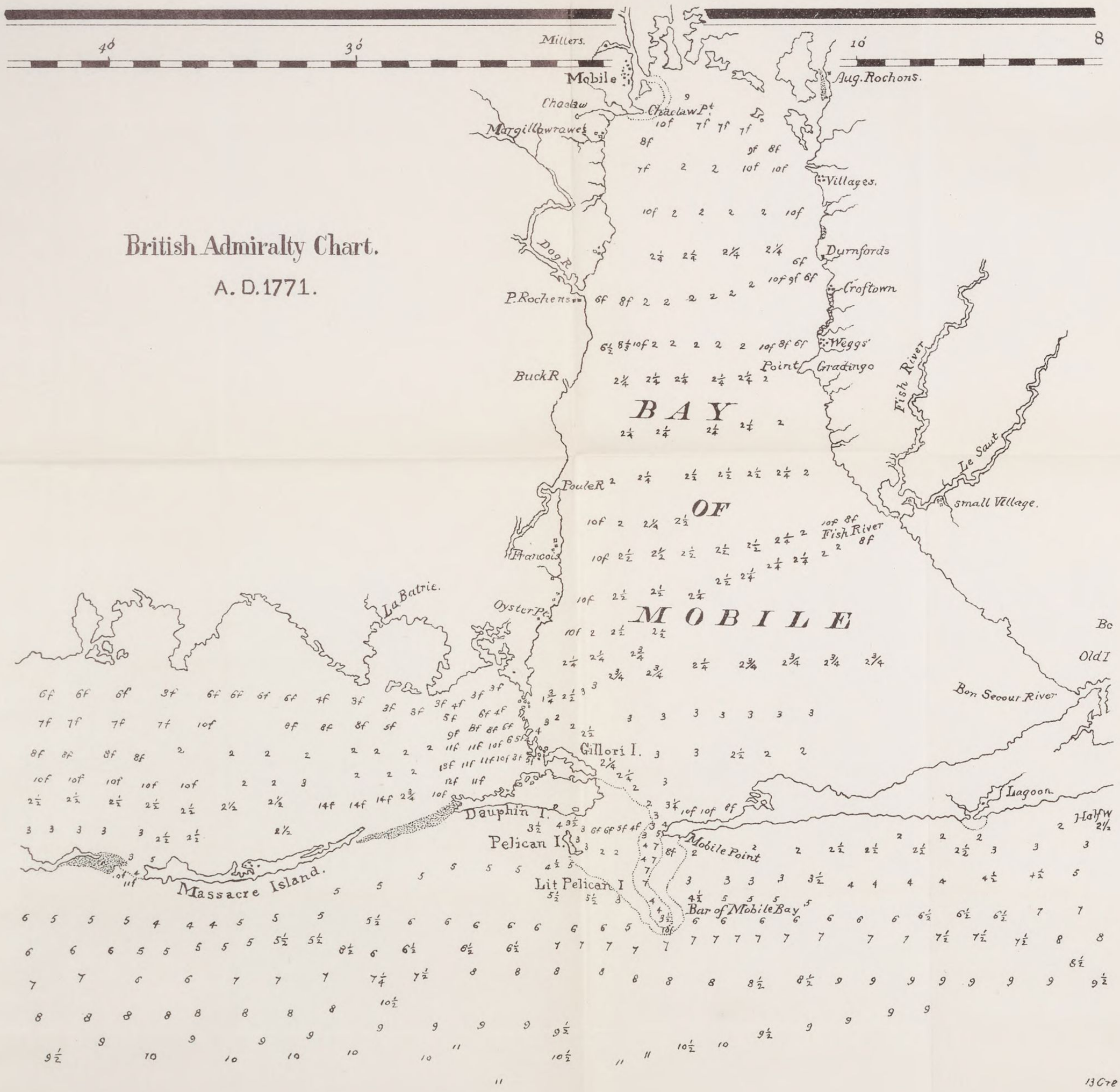
Wigwell & Creed Sculp.t

Eng 54 2



British Admiralty Chart.

A. D. 1771.



To accompany Report for Fiscal Year ending June 30th, 1896.

H. M. Robert
Major of Engineers, U.S.A.

1771.

ANDREW B. GRAHAM PHOTO LITHO. WASHINGTON, D.C.

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SENO MEXICANO

Plano de la Bahia DE MOVILA.

Situado el Fuerte del mismo nombre
en la latitud N. de 30° 36' 30"
y longitud de 81° 44' 00" al O. del meridiano de Cadiz.

Nota.

Los numeros de la sonda denotan pies ensetellanos y las letras iniciales la calidad del fondo: A arena: AF. arena y fango.

1 2

Escala de dos leguas.

Isla Delfina

Isla Pelicano

La Guillori

Barra

Pta. de la Movila

Boca Ciega

R.s del Buen Socorro

R.o de la Gallina

R.o del Garzo

R.o del Perro

Movila

Pta. Chacto

Aldeas

Pueblo

Pueblo

Rio del Pez

Rio del Salio

To accompany Report for Fiscal Year ending June 30th, 1896.

W. T. Rossell

Major of Engineers, U.S.A.

ANDREW B. GRAHAM PHOTO-LITHO WASHINGTON D.C.

A MAP OF Mobile Bay in the State of ALABAMA

comprising the Rivers & Creeks.

by

Curtis Lewis.

of Alabama.

Scale 3/8 of an inch to the Mile.

I denotes Island
S " Shoal
The depth of water is in feet.
The dotted part shews the extent of the shoals.

Directions

FOR COMING INTO MOBILE BAY, MOBILE AND BLAKELEY

In running in for the land or the bay of Mobile, should you make it to the Westward of the bar, the land will appear broken, as it consists of small islands, which occasion several small openings; if to the Eastward the land is uniform as far as Pensacola east, and covered with timber, the beach generally sandy and quite perceptible in clear weather, 8 or 10 miles distant. Dauphin island on the western point of the Bay, appears high and bluff- Mobile Point low and sandy with a single tree on the extremety, in the form of an umbrella and thinly wooded for 3 miles from the point, there are houses on the point and Dauphin Island - before you shoalen into 7 fathoms water, bring Mobile point to bear N½ W. and the East end of Dauphin island to bear N.N.W.½W. and steer in N.N.W. This course will run you over the Bar, on which you will have from 16 to 20 feet of water in good tides; after passing a small sand island on your larboard you are over the bar, and out of danger, with a shoal each side of you then haul up for the Pt. of Mobile. giving it a birth of 3 or 400 yards, then steer up the Bay as tracked on the chart - It is necessary to calculate for the Bay currents, as when the tide is flowing, you will drift to the westward, and when ebb to the eastward, until you get near Dog River bar, which extends across the Bay - where in 11 feet water, and 2 to 3 miles from the western shore, 7 miles from Mobile and 15 from Blakely, come to for a pilot. In beating across the bay, you can stretch within 2 to 3 miles of the shore with safety, except opposite Big Point Clear, and in Bon Secour Bay, keep Big and Little Point Clear in range, on north, the other South. It is also observed that there is a middle Ground shoal of 10 feet water laying to the Starboard of the track in running up the Bay, and opposite Big Point Clear and Fowl River, which is not shewn on the chart.

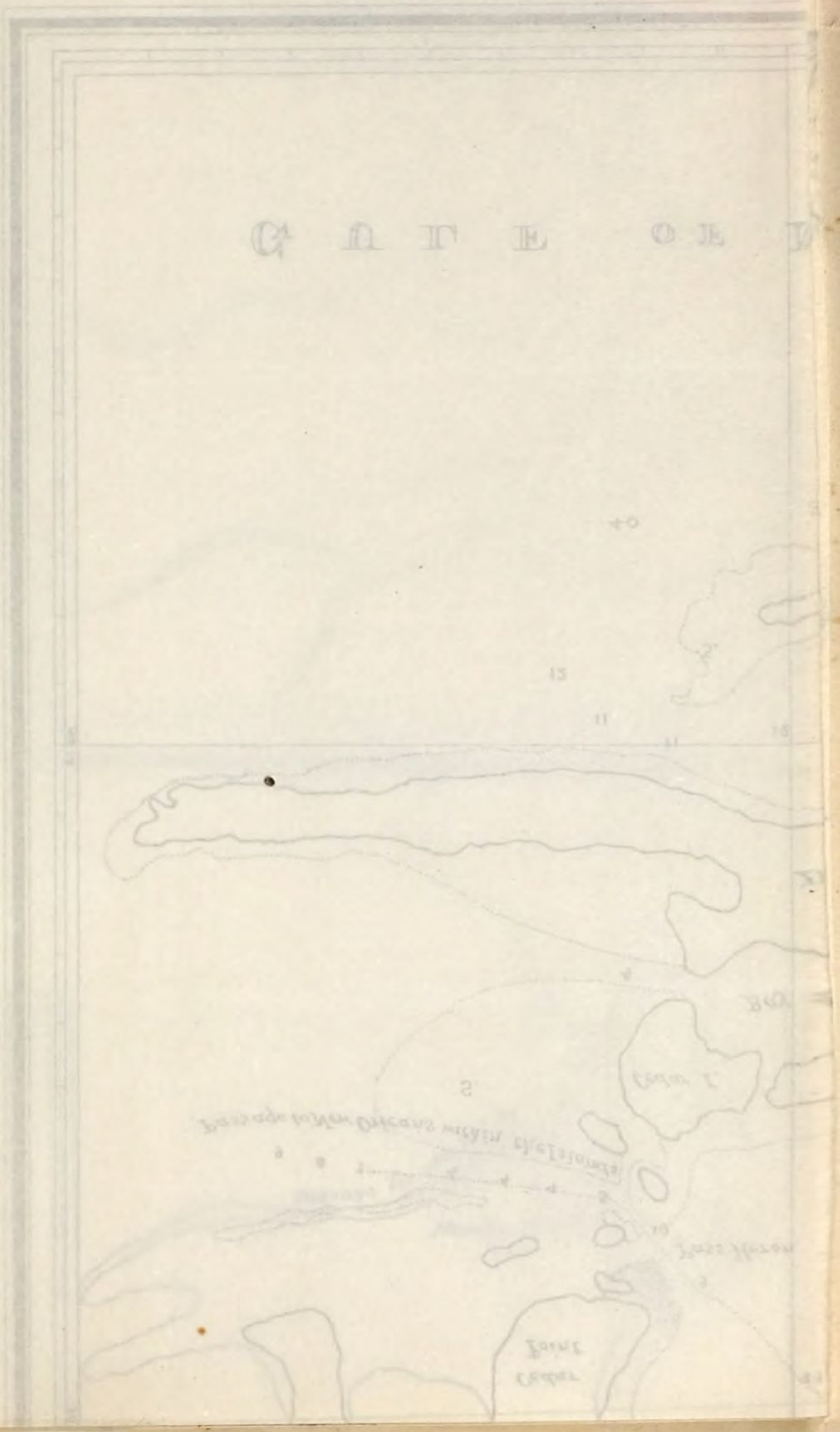
By Actual Survey - 1820.

Raft River Bay
Tensa R.
Bayou Soleine
Town of Blakely
Chickasaw Boge
3 Mile Creek
Mobile River
Spanish River
Tensa River
Apalatcha River
City of Mobile.
Pole cat Bay
Bay Minet.
Minet Creek.
Saw Mill.
Plantation
Plantation
Dog River Bar.
Dog River
Plantation
Deer River
Brickery
Red Bluffs
Williamsburgh
Big Point Clear.
Harbour
6 Ft.
Fowl River
Ships Track to Mobile and Blakely through Spanish and Tensa Rivers.
Fish River 5 Ft.
Plantation.
Mill Seat.
Settlements on this River.
Passage for small boats
Mon Louis Island.
MOBILE BAY
Cedar Point
Pass Heron
Passage to New Orleans within the Islands
Cedar I.
Bay 4 Ft.
Dauphin Island
Pass 7 ft.
Good Anchorage
Bonsecour's Bay.
River
Little Point Clear
Track
Navy Cove
Umbrella Tree
Mobile Point.
Pass 6 Ft.
Pelican Island
Pass 9 Ft.
Sand I.
Anchorage
Outer Bar
GULF OF MEXICO
Longitude West 88 from London

To accompany Report for Fiscal Year ending June 30th, 1896.

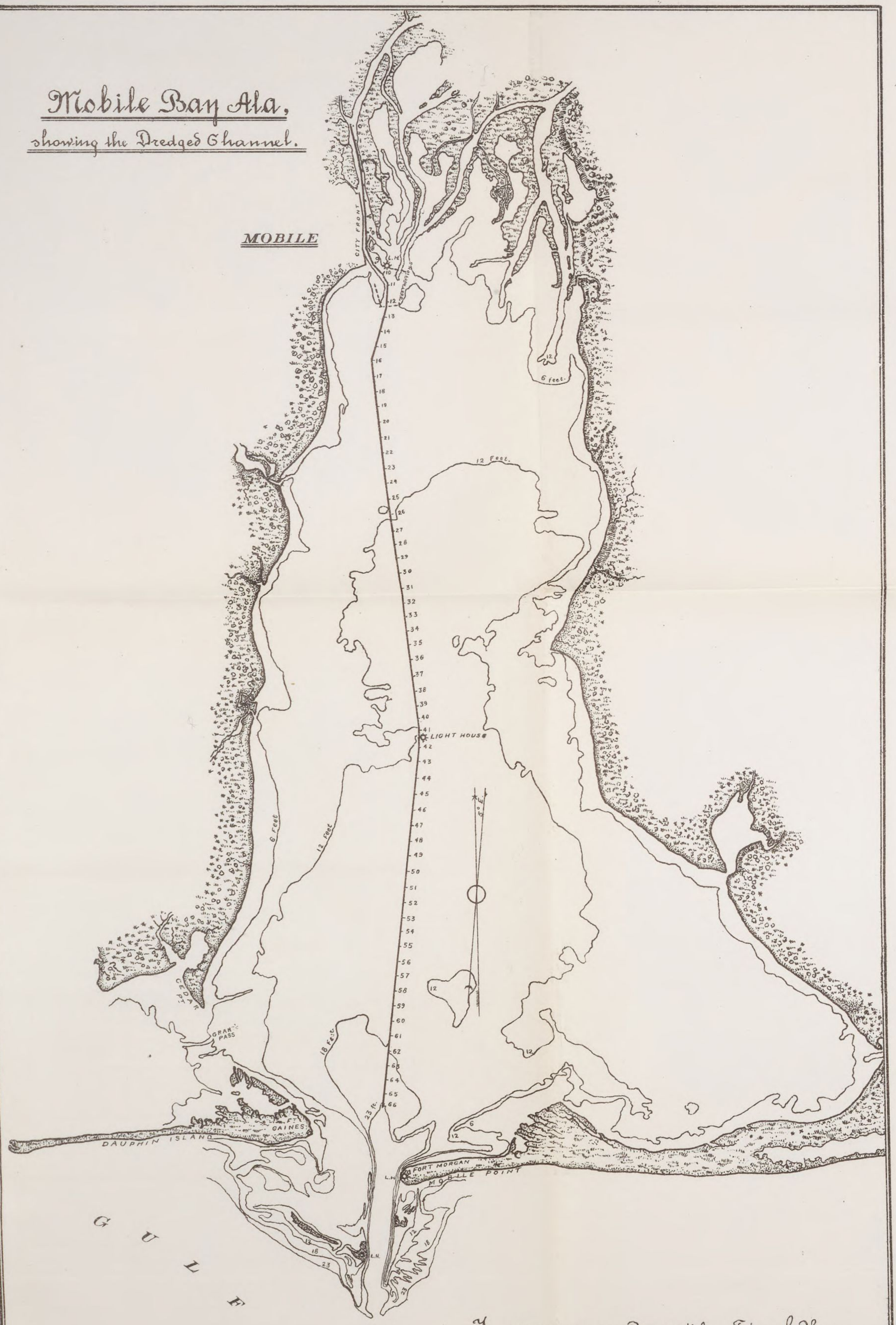
Wm. T. Poe
Major of Engineers, U.S.A.

ANDREW B. GRAHAM, PHOTO LITHO WASHINGTON, D.C.



Mobile Bay Ala,

showing the Dredged Channel.



To accompany Report for Fiscal Year ending June 30th, 1896.

Major of Engineers, U.S.A.

June. 1896.

ANDREW B. GRAHAM, PHOTO-LITHO. WASHINGTON, D.C.

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P 2.

IMPROVEMENT OF BLACK WARRIOR RIVER, ALABAMA, FROM TUSCALOOSA TO DANIELS CREEK.

The Black Warrior River drains a large section of North Alabama, estimated at about 8,000 square miles, the head waters of the smaller streams reaching nearly to the Tennessee River.

Surveys of it have from time to time been made, the most extensive reaching to the Forks of the Sipsey and Mulberry, 92¼ miles above the city of Tuscaloosa. At Tuscaloosa the name of the stream changes in the appropriation bills, that portion above the city being called the Black Warrior and that below the Warrior. The river is subject to frequent and rapid rises, and its discharge varies from about 400 cubic feet per second to more than 120,000 cubic feet per second. Along its banks are found large and valuable deposits of coal and the river bottoms are rich agricultural lands. It has never been navigable except at very high stages, owing to the Tuscaloosa Shoals, where there is a fall of more than 30 feet in less than 2 miles. The desire to get the products of the coal mines to tide water was the great cause of the improvement undertaken, and on January 12, 1896, the first tow of coal passed down, reaching tide water at Mobile on January 30, 1896. This small tow (one barge) was the subject of town meetings and an ovation at each town as it passed. It was looked upon as the first visible sign of what it is hoped and believed will be the source of prosperity to this section.

An act of May 23, 1828, declared the Black Warrior River, Alabama, free from all tolls, except such as might be allowed by act of Congress (sec. 5244, Rev. Stat., ed. of 1878, p. 1015).

The following examinations and surveys have been made:

1. An examination and partial survey of the river from Locust Fork to Tuscaloosa, 47½ miles, in 1874. (See Report of Chief of Engineers, 1875.)

2. A survey of the river from Tuscaloosa to the Forks of Sipsey and Mulberry in 1879. (See Report of Chief of Engineers, 1881.)

3. A survey of the river from Tuscaloosa to the Mulberry and Locust forks, a distance of 47½ miles, in 1895. (Published in House Ex. Doc. No. 259, Fifty-fourth Congress, first session.)

All plans and projects for the improvement of this river have contemplated the use of locks and dams.

After the first appropriation, by act of July 5, 1884, was made, which provided that the improvement should extend from Tuscaloosa to Daniels Creek, a distance of 15 miles, a project was proposed. This project proposed the use of locks with movable dams and was submitted December 19, 1885. The plans were submitted to a Board of Engineer Officers which met in Tuscaloosa February 10, 1886. This Board modified the project and recommended fixed dams with increased lift. New plans and estimates were submitted August 13, 1886, and were finally approved by the Board with slight modifications in their report of April 2, 1887. This report received the approval of the Chief of Engineers May 19, 1887.

The approved project was to construct five locks and fixed dams with a total lift of 52 feet. The locks were to be 52 feet clear width, 322 feet long between hollow quoins, available length 285 feet, and to have a depth of 6½ feet on miter sills. The locks were to be built with iron gates and of rock found in the vicinity. The dams were to be of the rock fill type. The estimated cost on the basis of ten hours for

a day's labor was $741,640. This will have to be increased, as a day's labor is now by law eight hours.

Work was begun in March, 1888, and has been carried on continuously since with the exception of a suspension from September 1 to October 20, 1890, caused by exhaustion of funds.

At this time three locks and dams have been completed and are now being used commercially. A small shoal below the first lock has been partially removed to the depth required to give 6 feet depth when the locks and dams are built on the lower river.

The rock used in the construction of Lock 1 was obtained from a quarry on shore, but for Locks 2 and 3 the rock was taken from the bed of the river. This last bed was uncovered by the cofferdam of Lock 3, and was found of superior quality.

I inclose herewith a profile of this portion of the river and a section and elevation of Lock No. 3, a plan of the river showing location of locks, yards, railroad track, etc., and cross section of the three dams built.*

Lock tenders' houses have been built, lock master and lock hands appointed, and the operation and maintenance of this portion of the work will be under the general law after July 1, 1896.

The land necessary for the fourth lock is now being negotiated for. It is 7.15 miles above Lock 3.

The cost of these three locks and the work of removing obstructions from the pools and below Lock 1 has been $574,879.02.

The following appropriations have been made:

By act of—	
July 5, 1884	$50,000
August 5, 1886	56,250
August 11, 1888	100,000
September 19, 1890	150,000
July 13, 1892	200,000
August 17, 1894	37,500
June 3, 1896	10,000
Total	603,750

The total commercial traffic through the three locks up to the end of the fiscal year ending June 30, 1896, amounts to about 2,628 tons of coal and 85,000 feet B. M. of lumber.

Money statement.

July 1, 1895, balance unexpended	$50,892.61
Amount appropriated by act of June 3, 1896	10,000.00
	60,892.61
June 30, 1896, amount expended during fiscal year	32,021.63
July 1, 1896, balance unexpended	28,870.98
Amount (estimated) required for completion of existing project	190,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	190,500.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

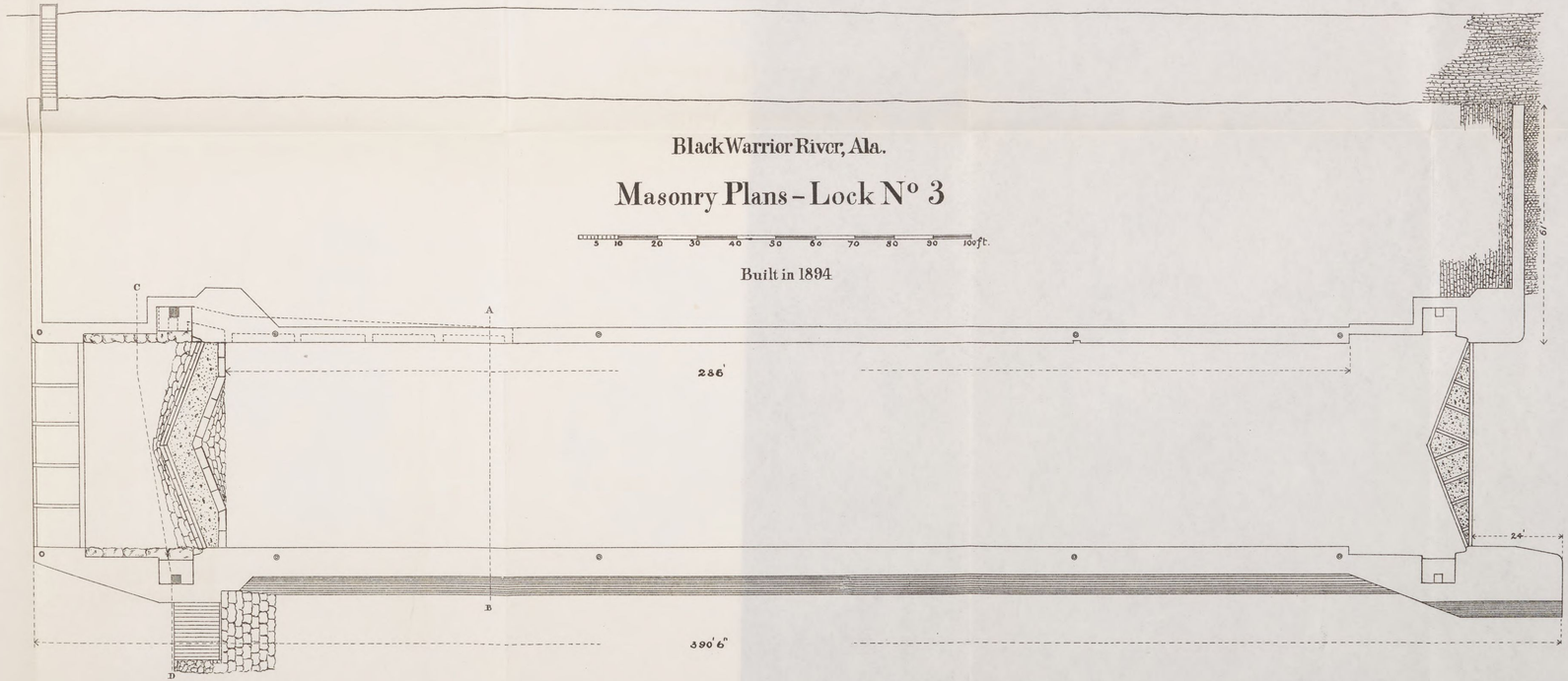
* Map showing improvements at Tuscaloosa, Ala., not printed.

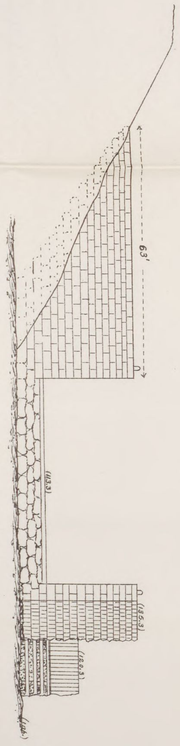
Black Warrior River, Ala.

Masonry Plans – Lock N° 3

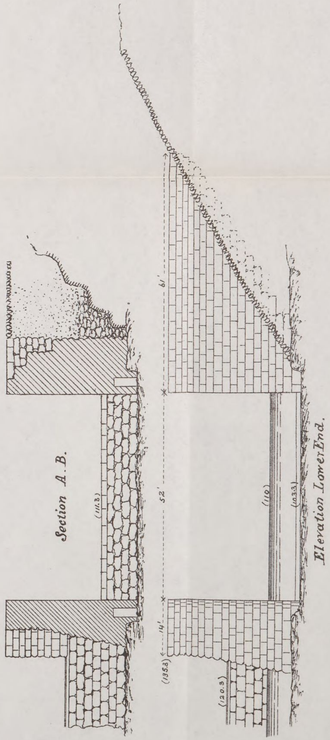
5 10 20 30 40 50 60 70 80 90 100ft.

Built in 1894









To accompany Report for Fiscal Year ending June 30th 1896.

Wm. A. Pruell

Major of Engineers U.S.A.

Section through axis showing Bank Wall

Eng 54 2

ANDREW B. GRAHAM PHOTO-LITHO WASHINGTON, D.C.

Improvement of Black Warrior River, Alabama.

Cross-sections of Dams.

Scale.

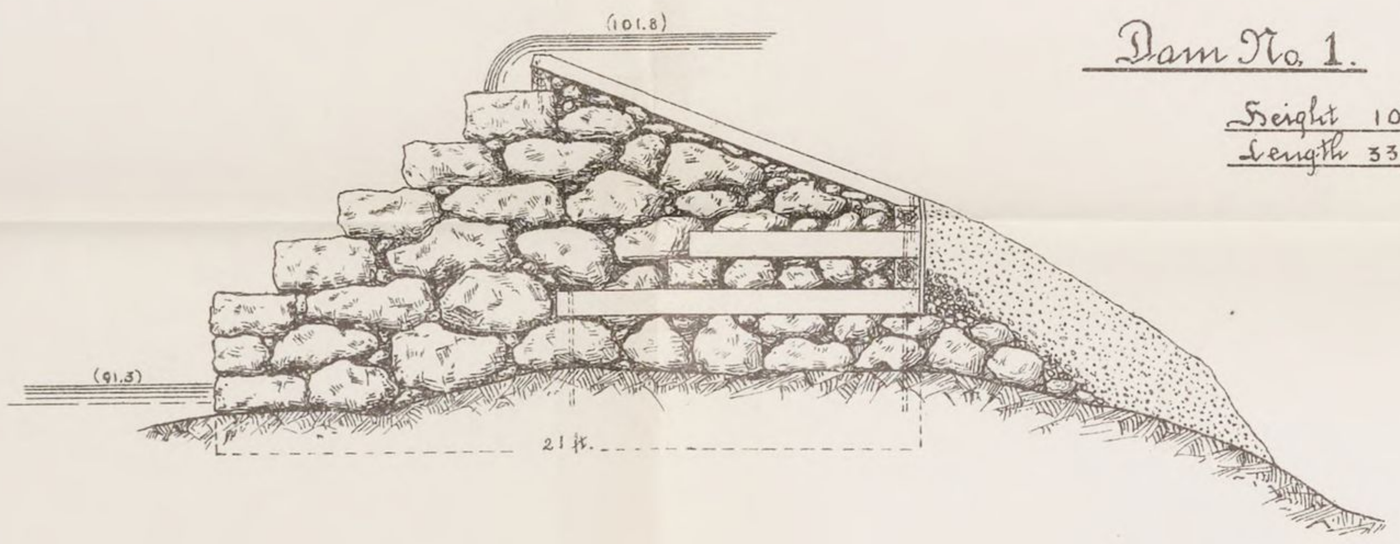
0 4' 8' 12' 16' 20'

To accompany Report for Fiscal Year ending June 30th. 1896.

Wm. T. Russell
Major of Engineers, U.S.A.

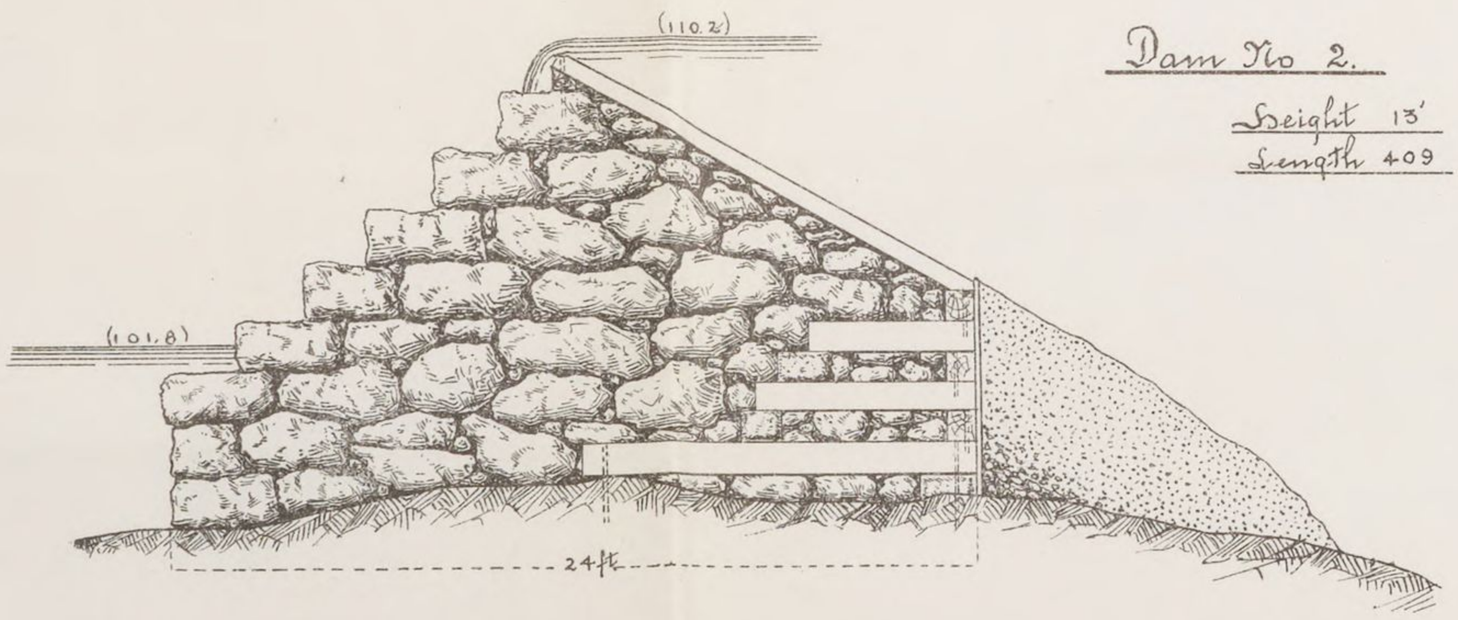
Dam No. 1.

Height 10'
Length 339'



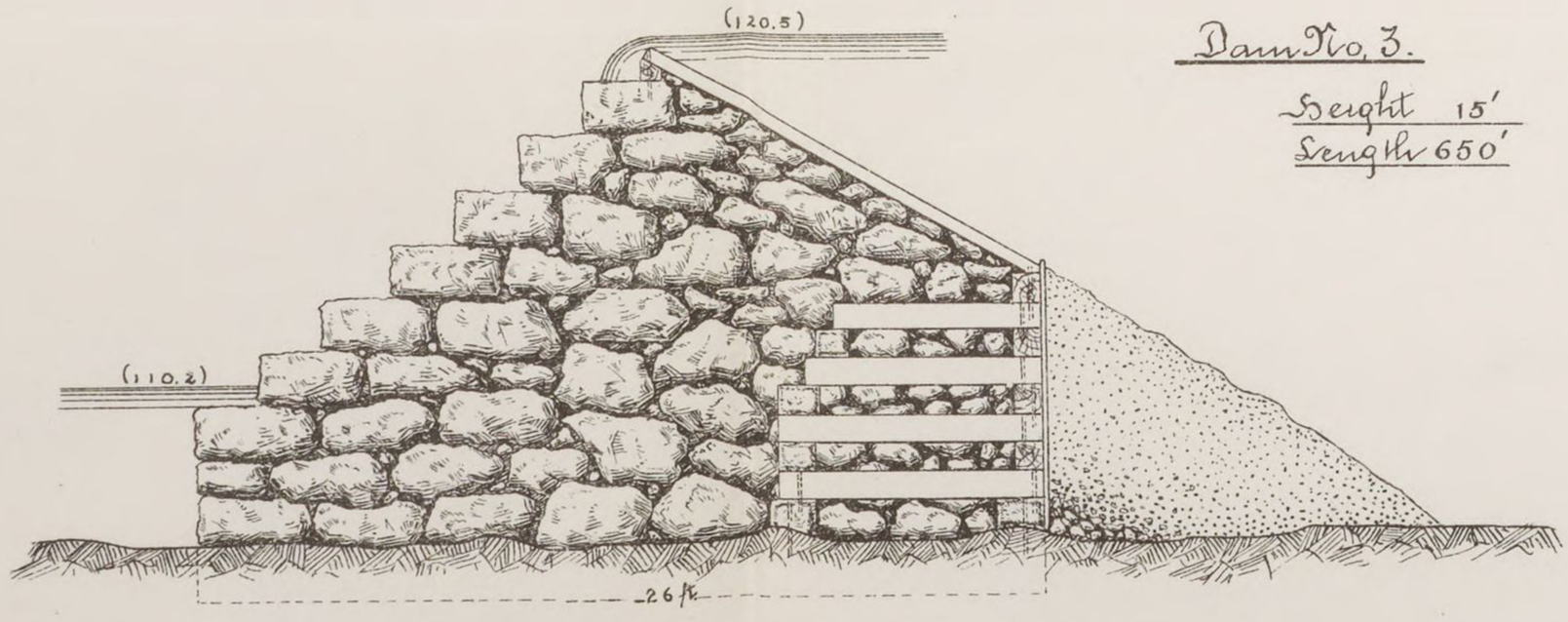
Dam No 2.

Height 13'
Length 409

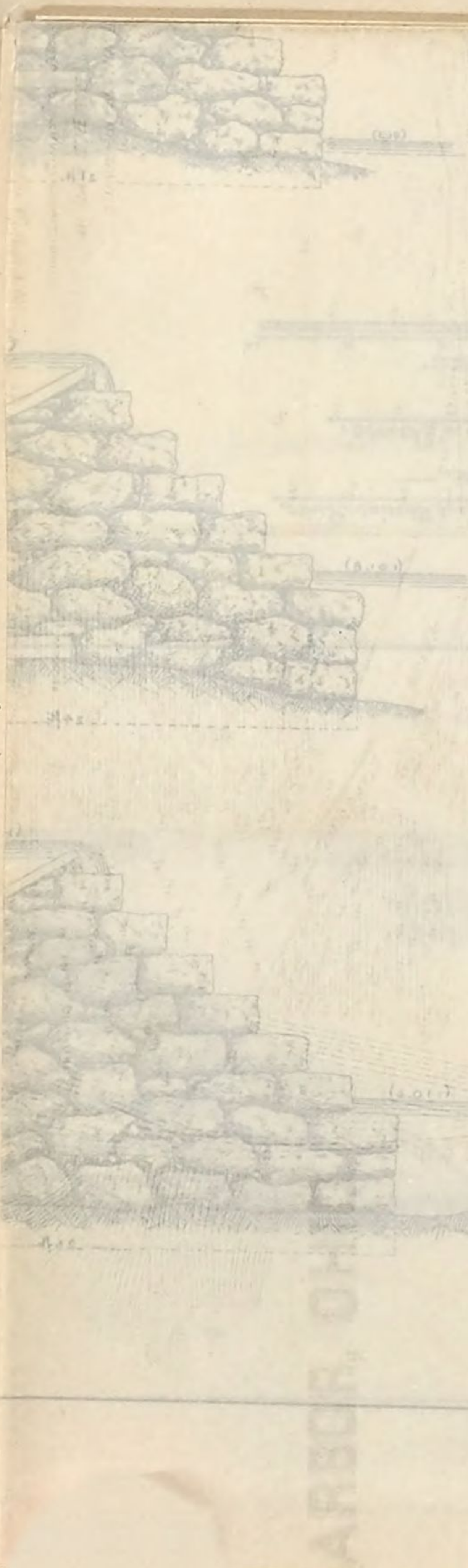


Dam No. 3.

Height 15'
Length 650'



ANDREW B. GRAHAM, PHOTO-LITHO. WASHINGTON, D.C.



P 3.

IMPROVEMENT OF WARRIOR AND TOMBIGBEE RIVERS, ALABAMA AND MISSISSIPPI.

This system of rivers forms the highway for the coal, etc., coming down the Black Warrior River, as well as the natural communication for western Alabama and eastern Mississippi that lies contiguous to the upper Tombigbee.

The work done on this system is divided into sections, as follows:

(*a*) Warrior River, from the mouth to Tuscaloosa, a distance of 130 miles.

(*b*) Tombigbee River, from mouth to Demopolis, a distance of 191 miles.

(*c*) Tombigbee River, from Demopolis, Ala., to Columbus, Miss., a distance of 156 miles.

(*d*) Tombigbee River, from Columbus to Fulton, a distance of 144 miles.

(*e*) Tombigbee River, from Fulton to Walkers Bridge, a distance of $24\frac{3}{4}$ miles.

(*a*) WARRIOR RIVER, ALABAMA.

This stretch of river 130 miles long forms the second link in the chain from the Warrior Coal Fields to tide water at Mobile, Ala. The first survey of this river with a view to its improvement was made in 1874.

This stretch of river is subject to many and rapid rises, the difference between the high and low water at Demopolis being 60 feet.

It has been navigable on 10-foot rises and generally through the winter and spring. During the lower stages of summer and fall the river is not as a rule navigable.

With the small low-water discharge it was impossible to improve navigation for all stages. The boating season has an average duration of five months. During this season the depths range from 10 to 40 feet and navigation is for the most part unobstructed; the greatest trouble is found from the sharp bends. The width was obstructed by overhanging trees. Below a 10-foot stage snags are troublesome and dangerous and below 5-foot stage navigation practically ceases. This was the condition of the river when the survey of 1874 was made.

The first appropriation made by Congress for this river was by act of March 3, 1875. Under this appropriation a project was prepared and approved as follows:

To deepen the bars by jetty construction, remove snags and cut down overhanging trees, to obtain for small boats a low-water channel 80 feet wide by 4 feet deep, at an estimated cost of $151,103.

Appropriations were made as follows:

Warrior and Tombigbee rivers:	
March 3, 1875	$25,000
August 14, 1876	15,000
June 18, 1878	28,000
March 3, 1879	20,000
Warrior River:	
June 14, 1880	20,000
March 3, 1881	10,622
August 2, 1882	10,000
July 5, 1884	12,000
August 5, 1886	18,750
August 11, 1888	18,000
Total	177,372

Of this amount $89,372 was appropriated for the Warrior River and $88,000 for the Warrior and Tombigbee jointly.

The execution of the project was begun in June, 1875, and continued for an average annual period of four months to December 10, 1885, and for three months in 1887, the work being chiefly confined to the removal of snags and overhanging trees. Jetties were built to deepen the water over the bars at 49 places. They resulted in an increase of depth of 1 to 1½ feet. These works were of temporary construction and in some cases were lost by bank erosion.

On December 24, 1889, a project for improving this river by dams and pneumatic gates was submitted. This project was in the line of giving slack-water navigation throughout the year from the coal fields to Mobile. The estimated cost was $577,000, of which $399,000 was for the dams and pneumatic gates. Later it was proposed to substitute for dams and pneumatic gates an improvement by locks and dams similar in construction to those now built on the Black Warrior River.

The fall for this distance was found to be 60.2 feet. I am therefore of the opinion that 6 locks and dams will be needed. The cost of this improvement must be increased as follows:

6 locks and dams, at $200,000	$1,200,000
Contingencies, engineering expenses, etc	120,000
Total	1,320,000

In view of the fact that coal is now being brought down from above Tuscaloosa the improvement by snagging and regulating has become much more important and the work now being done is with a view of accommodating coal tows when the river is at about a 10-foot stage.

The following appropriations have been made by Congress:

September 19, 1890	$45,000
July 13, 1892	75,000
August 17, 1894	40,000
June 3, 1896	70,000
Total	230,000

No work has yet been done toward building a lock and dam, but during the coming fiscal year the site for the lowest one will be selected and preliminary work done.

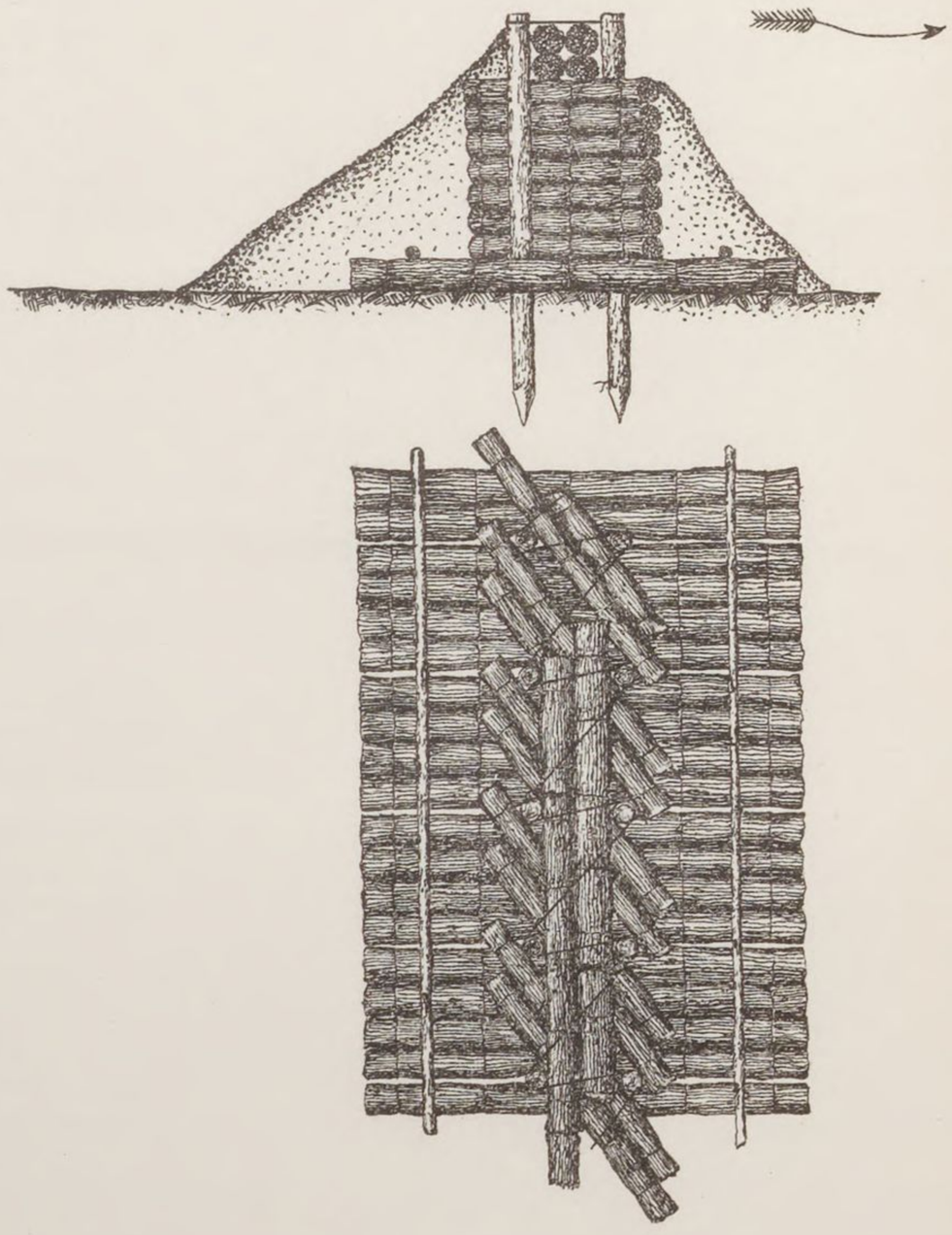
Under these appropriations up to June 30, 1895, the following work was done:

A new plant has been prepared for the work.

Snags and stumps removed		14,702
Sunken logs removed		132
Logs on banks cut up		872
Trees felled, cut up		15,490
"Slip-ins" removed		822
Trees trimmed and deadened		1,404
Drift piles removed		31
Rock removed from bars	cubic yards	5,004
Gravel removed from bars	do	28,059
Dams, dikes, and jetties built	linear feet	2,538
Masonry removed from piers of Forrest Bridge	cubic yards	2,099
Revetment of caving banks laid	square yards	6,491

During the present fiscal year the following has been done:

Overhanging trees cut	3,167
Trees cut and pulled back	1,274
Stumps leveled, removed	2,728
Snags removed	4,615
Logs removed from river	368
Logs on banks cut up	467



General Section and Plan of Dyke used on the Warrior River.

Gum piles, 8' to 12' long, and 4" to 6" diameter are driven 3' to 4' with heavy hand-mauls. They are in two rows, 1'6" apart and 3' in the row. A mat 10' square is made about the piles and sunk with gravel, which, in case of swift water, is sacked. On the mat, the fascines are built up diagonally, as shown, each course being covered with gravel. At the top, the fascines are laid wholly within the piling and secured with wire wrapped around the pile-heads.

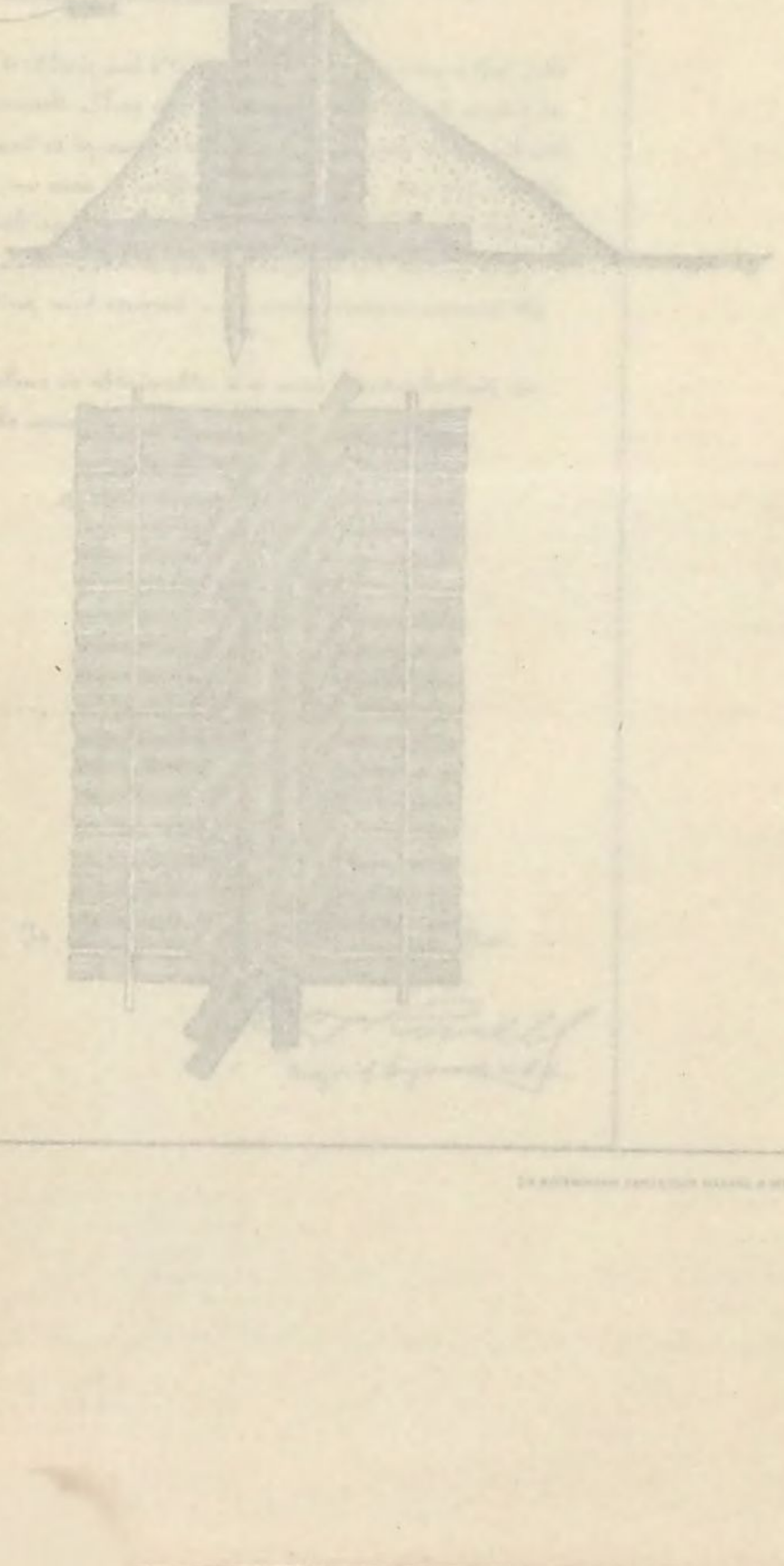
Where heavy stone is obtainable, it is used as a top ballast, in preference to the wire fastening.

Scale 6 ft per inch

To accompany Report for Fiscal Year ending June 30th, 1896.

Major of Engineers U.S.A.

ANDREW B. GRAHAM, PHOTO-LITHO. WASHINGTON, D.C.



Drift piles removed		2
Slip-ins removed		158
Gravel removed	cubic yards	9,550
Rock removed	do	358
Jetty built	linear feet	283
Jetties repaired	do	304
Shore protection	do	150
Dam built	do	285
Earth excavated	cubic yards	2,500
Brick removed from Forrest piers	do	428

The total amount expended on improvement up to June 30, 1896, is $141,892.90.

Money statement.

July 1, 1895, balance unexpended	$51,603.26
Amount appropriated by act of June 3, 1896	70,000.00
	121,603.26
June 30, 1896, amount expended during fiscal year	33,496.16
July 1, 1896, balance unexpended	88,107.10
Amount (estimated) required for completion of existing project	347,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	200,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

(*b*) TOMBIGBEE RIVER FROM ITS MOUTH TO DEMOPOLIS.

This portion of the Tombigbee River forms a part of the line which, with the Black Warrior, Warrior, and Mobile rivers, gives an outlet to the coal from the Warrior fields.

The first surveys for improvement were made in 1870, and from that time to 1888 work of a temporary character only was done.

By act of August 11, 1888, a survey was directed to be made. The report was submitted December 24, 1889. The project proposed was to obtain a channel 6 feet deep at ordinary low water by the removal of snags, logs, and overhanging trees, dredging, bank revetment, and the construction of locks and dams. The length of this section of the river is 191 miles and the estimated cost $508,808.

Appropriations have been made as follows:

Act of September 19, 1890	$55,000
Act of July 13, 1892	125,000
Act of August 17, 1894	75,000
Act of June 3, 1896	75,000
Total	330,000

Actual operations were begun in July, 1891, and have been continued since whenever the stage of water would permit.

The following work has been done to June 30, 1895:

Overhanging trees felled and removed		2,684
Snags and stumps removed from river		4,223
Old jetties repaired	linear feet	3,492
Rock blasted and excavated	cubic yards	2,944
Material dredged (marl, clay, gravel, sand)	do	37,573
Shore protection built	linear feet	257
Sunken barges removed		3
Logs on banks cut up		3,064
Piles of drift removed		43
Piles driven		1,371

Operations during the present fiscal year may be divided into two parts:

(1) Lock and Dam No. 1, at McGrew's Shoal, 111 miles from Mobile.

(2) Snagging and dredging carried on with snag boat *Tombigbee* and steam dredge *Black Warrior*.

The site for Lock and Dam No. 1 was carefully surveyed, and detailed plans for same have been submitted and approved. Work has been begun on the cofferdam, and the necessary buildings for the accommodation of men and materials have been built.

During the fiscal year the dredge *Black Warrior* has been engaged at work at Harwells Bar and St. Nicholas Bar in dredging and rock excavation. Sketches of these bars are herewith inclosed.*

The *Tombigbee* cleaned the river, so far as snags, etc., were concerned, to Double Bar, 159½ miles from the mouth, and repaired some jetties at Peaveys. I inclose a sketch of Peaveys Shoal.

The following work was accomplished during the working season of 1895–96:

Overhanging trees felled and removed	131
Number of cuts made	339
Stumps and snags removed from river	1,583
Snags cut	2,568
Material dredged (marl, clay, gravel, sand) ..... cubic yards..	11,708
Trees trimmed	585

The total amount expended to June 30, 1896, was $153,181.59.

I append to this report the report of Assistant Engineer T. W. Nicol, which gives interesting details of this work.

Money statement.

July 1, 1895, balance unexpended	$135,419.39
Amount appropriated by act of June 3, 1896	75,000.00
	210,419.39
June 30, 1896, amount expended during fiscal year	33,600.98
July 1, 1896, balance unexpended	176,818.41
Amount (estimated) required for completion of existing project	178,800.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	178,800.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

COMMERCIAL STATISTICS.

Articles.	1896.	1895.	1894.
	Tons.	*Tons.*	*Tons.*
Cotton	8,350	7,000	6,900
Grain	4,420	5,010	5,324
Iron	92	100	92
Lumber	66,360	12,175	12,175
Merchandise	13,744	13,006	14,055
Total	92,866	37,291	38,546

* Not printed.

REPORT OF MR. T. W. NICOL, ASSISTANT ENGINEER.

MOBILE, ALA., *July 1, 1896.*

MAJOR: I have the honor to submit my report on the improvement of the Tombigbee River from Demopolis to its mouth for fiscal year ending June 30, 1896.

The Tombigbee River, formed by the junction of the little Tombigbee and Warrior rivers, flows in a southerly course forming the boundary line between Marengo and Clarke counties on the east, Sumpter, Choctaw, and Washington counties on the west, and in conjunction with the Alabama River forms the Mobile, 45 miles from its mouth. The only tributary supplying any considerable water and which contributes in any measure to increased section is the Sucarnochee, 169.3 miles from the mouth. This stream, however, seldom causes more than local oscillation in the Tombigbee. The other streams, all of which are small and nearly dry at low water, have short contracted sheds and mostly have their sources at the near-by hill slopes. The stream is almost entirely fed from local rainfall, and in consequence the oscillation is spasmodic and of short duration, except during winter rains. The total length of the stream, according to authentic surveys, is 185 miles, and the total fall 27.23 feet. The Tombigbee River in its general characteristics is not unlike most Southern alluvial streams. Its course, whilst confined to a comparatively narrow bottom, is found to have ricochetted from side to side of its lower valley, impinging upon the base of the primeval hill on the one side and thence crossed the valley and built up an alluvial bed, causing the numerous shoals and bars through which the stream at low water is constantly wrestling with dynamic force to maintain its normal section.

The stream in its course passes through several distinct geological formations. From Demopolis for 20 miles it skirts the rotten limestone formations found extending eastwardly across the country to the Alabama River. Thence its fall has washed into the base of the lignite deposits of Clarke and Choctaw counties. Still lower down its cut has developed the chalky black clay bluffs which regularly alternate from the bluff on the one side to the low alluvial on the other. From Barney's Shoal (113.5 miles from the mouth) the slope has descended to an elevation developing the outcrop of quite extensive marl deposits. From the region about Tuscahoma, the low-water slope has again found the foothills of the rotten limestone range mentioned above, and which form part of the watershed between the waters of the Tombigbee and Alabama rivers. At McGrew's Shoal the stream appears to have had its last battle in its attempts to carve out channels along the foothills and its low-water surface is grudged to such an extent that the limestone extends entirely across the stream, leaving a 3-foot navigation pass not over 100 feet wide. This rock shoal, on which some little excavation has been done, has been a constant menace to low-water navigation since the introduction of steam craft on the river. Much time is lost when the stage is low, or the gauge reads 1.25, and thousands of dollars have been lost to navigation interests.

McGrew is practically the foot slope of the Tombigbee at low water, and can properly be called tidal. From a point 3 miles below McGrew the low-water line is below the rock formation, and the river thence to its mouth apparently takes its course through material deposited by the high water in successive years past. At three points, Jackson, Carneys Bluff, and Owen Bluff, has the river invaded the foothills, and in each case the formation has proved to be gravel embedded in clay or sand. The Tombigbee does not carry in suspension an extreme amount of sediment, and the maximum is when the stream has attained an elevation 2 to 3 feet below the normal bank, say 25 feet above low water.

From Demopolis to Thompson Shoal, while the slope is much in excess of that lower down, it will be easier to maintain perfect regimen as to banks. But as we descend, the concave side of the bends show the inroads of the higher water erosion. At several points above McGrew the stream trunk is annually changing base, and from a point 3 miles below Jackson to within 10 miles of the mouth the bank erosion is such as to demand special attention and treatment. These bends, washing, sloughing, and in some cases caving, will need to be protected by mattressing. The normal radius around bends must be preserved. Wild cane and willow are to be had in abundance for the work, and from McGrew Shoal to the mouth 52,800 linear feet will be required, at an outlay of $39,600.

The 0 of the gauge fixed at McGrew is the mean low tide datum at Mobile, and from a series of observations during the extreme low water of 1894–5 the lowest recorded reading was 1.25. From reliable information from steamboatmen I am quite convinced that during the prevalence of north winds the low stage at some time has dropped below this record. This elevation is due also to frictional resistance and a tortuous course. No series of simultaneous gauge readings have been taken at Mobile and McGrew, but the diurnal tidal effects have been found to be uniform, and I feel warranted in calling McGrew tidal at low water.

The summit of low water at Demopolis is 27.23, or an average slope to McGrew of 0.23 per mile. This slope is not distributed with equal ratio, as shown by the following table of comparison:

From—	To—	Distance	Total fall.	Average per mile.
		Miles.	*Feet.*	*Feet.*
Demopolis	Lone Brother Bar	23	4.69	0.20 ±
Lone Brother Bar	Breckenridge Landing	18.3	10.56	.57 ±
Breckenridge Landing	Tuscahoma	19.7	4.25	.21 ±
Tuscahoma	Woods Bluff	19.8	3.33	.16 ±
Woods Bluff	Thompsons Shoal	19	2.42	.12 ±
Thompsons Shoal	McGrew Shoal	19.2	.73	.038±
McGrew Shoal	Mobile	111	1.25	Tidal.

The high water of 1874 spread over a large proportion of the lower lands, but no reliable water marks were established. This extreme elevation was caused by simultaneous rise in the Alabama, causing the water to back up. The high water discharge was taken at McGrew Shoal in 1893, when the gauge read 32 and showed 100,000 cubic feet per second. The most reliable information would indicate an elevation of 36° as the high water of 1874.

Low-water discharge at the mouth is recorded as 1,800 cubic feet per second. In 1894 at Peavey's Shoal, 5.5 miles above McGrew, careful observations were taken when the gauge read 1.25 at the latter place, resulting in a discharge of 1,400 cubic feet. The observations were taken under most favorable conditions, between almost parallel lines and flat cross-section over a 400-foot base, with repeated trials. I regard the result as reliable.

IMPROVEMENT.

Prior to the end of fiscal year ending June 30, 1895, the plan of improvement was snagging, dredging bars, and the projection of jetties of light structure in an endeavor to maintain low-water navigation for a depth of 3 feet. During the working season of 1894–95 the snag boat *Tombigbee* was placed in commission, and starting from the mouth worked continuously up stream, closing the season of low water at Turner Shoal, 93.4 miles from the mouth. The combination snag and dredge boat *Black Warrior* was also set to work, and after assisting the *Tombigbee* for 2 months was sent to Peavey's Shoal, where she dredged a channel to 6 feet depth, 2,000 length, and 75 feet wide, constructing 2 jetties 1,450 feet long, as appears on map of this shoal. Some bank work was done, cutting leaning timber on banks from Jackson to Peavey's Shoal. The tabulated result of this work will be found in Report of Chief of Engineers for 1895, pages 1694–1695, part 2.

During the fiscal year ending June 30, 1896, or the low-water season of 1895–96, both the *Tombigbee* and *Black Warrior* were placed in commission. The *Tombigbee* closed the low-water snagging season's work on January 1, 1896, at Double Bar, 159.5 miles from the mouth, resulting in a clear channel up to this point, so far as snags obstruct navigation. The *Black Warrior* was placed in commission in October, 1895, and sent to Harwells bar to complete that channel, after which she went to Point St. Nicholas and dredged that channel, completing a 6-foot depth of water from the mouth to McGrew Shoal. On completion of this latter work the boat was sent to Double Bar to assist the *Tombigbee.* Both boats returned to Mobile January 1, on the rise of the river. Early in June of this year both boats were placed in commission, the *Tombigbee* to resume her work at Double Bar, working upstream, and the *Black Warrior* to undertake dredging soft-rock shoals at Osage Bar. The oscillation of the river has been such that neither boat has done much work beyond removing a few snags and repairing one jetty end at Osage. The river is now declining and work will be resumed. The *Tombigbee,* it is hoped, will reach Demopolis this low-water season, and the *Black Warrior* succeed in relieving navigation temporarily at Osage, Turner, Thompson, and Woods Bluff, the present outlined plan. Attention is called to plats showing operations at Harwell's Bar and Point St. Nicholas Bar. The following table shows the results of work performed by the two boats for the fiscal year ending June 30, 1896:

Overhanging trees felled and removed	131
Number of cuts made	339
Stumps and snags removed from river	1,583
Snags cut	2,569
Material dredged (marl, clay, gravel, sand) cubic yards	11,708
Trees trimmed	585

M'GREW LOCK WORKS.

During 1893-94, under direction of Lieut. E. E. Winslow, Corps of Engineers, surveys and substratum examinations were made at McGrew Shoal to determine the feasibility of constructing a concrete lock and dam of 12 feet lift to afford a navigable channel of 6 feet as high up as Naheola Shoals 75.7 miles from McGrew. The field work having been completed, plans were made and duly submitted and approved by the Chief of Engineers and work ordered done.

During 1895-96 buildings were erected for laborers, mechanics, keepers' dwelling, blacksmith shop, and material storehouses—the keepers' dwelling to be occupied by engineers and superintendents during construction of the lock and dam. The erection of these buildings and clearing of ground cost $3,419.35. Contracts for cement, gravel, and sand, as well as most of the machinery plant, have been made.

On the 20th of May work was formally commenced with the erection of machinery plant and necessary additional buildings for machinery. The following work has been done at the close of the fiscal year. Cement house extended 46 feet, one additional cement house, 800 linear feet of narrow gauge railway laid, excavations made for concrete house foundations, shore line cleared up, blacksmith shop forge built, machinery overhauled and cleaned, closets and bunks and tables erected, concrete house framed ready for erection, lumber assorted, fuel delivered, 50,000 feet B. M. framed and launched in cofferdam, and much general work attending the preparation for active work. The following table shows items of cost at McGrew Shoal closing fiscal year:

Buildings erected and clearing done	$3,419.35
Lumber received, 198,292 feet, B. M	2,474.68
Tools and implements, fittings and hardware	1,197.37
One new barge	595.00
Shingles for extra buildings	122.40
One mile of steel rails and fastenings	824.35
Outfit boarding for 80 men	506.11
One 8-ton engine	1,994.00
Engineering and superintendence	875.00
Labor	1,218.76
Purchase price two sides of land	152.00
Subsistence for men	494.15
Miscellaneous	24.00
Total	13,897.17

Contracts for 13,000 barrels of Lagerdorfer (German Portland) cement has been concluded, and tenders for 10,000 cubic yards of gravel and 5,000 cubic yards of sand have been received and accepted. One delivery of 1,200 barrels of cement has been received and is now undergoing specification tests.

The cofferdam will be the ordinary cribbed timber type, two parallel walls filled with rotten limestone, holding between them a clay bulkhead. The site of lock, as already shown on plans submitted, being next to the left bank and near it, only three sides of a cofferdam will be needed, with sufficient base in the event of extreme summer oscillation pending the raising of concrete walls. It is proposed to push this work during the present low stage, with the endeavor to raise the walls as high as possible.

Pending the completion of lock and dam, the claims of low-water navigation are such that one section of the river has been considered worthy of temporary relief. At the lowest stage (the duration of which is annually three months) steamboats can not ascend above Pearsons Shoals (or Gays Landing, 130 miles from the mouth) on account of a number of rocks and sand bars on which only 3 feet of water is found. Of these shoals, Wilson, Baker, Thompson, Turner, Osage, and Woods Bluff offer most constant obstruction and need the temporary relief mentioned. This work is outlined for the Black Warrior to be dredged to a depth of 4 feet at extreme low water. No temporary relief has been entertained for the river above Pearsons Shoal, as the cost would be too great, in view of the proposed lift by locks and dams.

RESOURCES.

The valley of the Tombigbee sends to Mobile cotton, corn, and timber, and the Tombigbee River is the only avenue of transportation to the seaboard. During the prevalence of low water, which occurs just when the principal staple, cotton, is ready for market, there is no possible egress or ingress to the 70 miles above Pearsons Shoal, and both cotton and return merchandise are hauled 25 to 35 miles across

hilly country, to either the Mobile and Ohio or Mobile and Birmingham railways, paying freight rates on a noncompetitive basis. At Jackson, in the lower river, where the Mobile and Birmingham Railroad crosses, the rate per bale of cotton is 50 cents, while above Pearsons Shoal cotton is hauled 30 miles to the Mobile and Birmingham Railroad, and then pays $1.50. It is estimated that during this embargo above 15,000 bales of cotton annually are carried out of the valley to the railways, resulting in an excess of cost to the shipper on cotton alone of $30,000. Awaiting the canalization of the Tombigbee and Warrior is the transportation of the inexhaustible coal measures of the Warrior coal fields of Alabama, the largest in extent in the State. It is demonstrated that with 6-foot channel from the coal fields to the seaboard, coal can be transported at a rate hitherto undreamed of, and the railway as a competitor made to serve as a factor by which lowest rates would be enforced.

Upon the completion of Locks 1, 2, and 3 at Tuscaloosa, by which the lower edge of the coal outcrop is reached, two mines were opened, delivering their output directly into tide-water barges. In January, 1896, the first trial barge was towed to Mobile, upon a medium stage of water, to test the handling of tows around bends. The trial was eminently successful, and there can be little question now that with a 6-foot maintained low-water channel coal can be transported to Mobile at a tonnage cost as cheap or cheaper than any other place in our country.

The valley slopes of the Tombigbee are covered with long-leaf yellow pine, and the bottoms with a great variety of hard woods, such as white oak, ash, walnut, and hickory. These timbers at medium and high stages are floated to Mobile. At low water the bars will not permit floating, and at such times timber famines occur with the mills at Mobile. Following will be found tables of products shipped out and received on the river from Demopolis to the mouth. It must be also understood that the water intercommunication from both Little Tombigbee and Warrior rivers is dependent upon a safe and reliable boating stage on this stream, which under present conditions is now prohibited for six months annually.

Table of timber products.

	Pieces.	Value.
Hewn pine, oak, poplar, and gum	7,000	$80,000
Sawed pine	11,000	38,500
Round pine logs	35,000	60,000
Total	.....	178,500

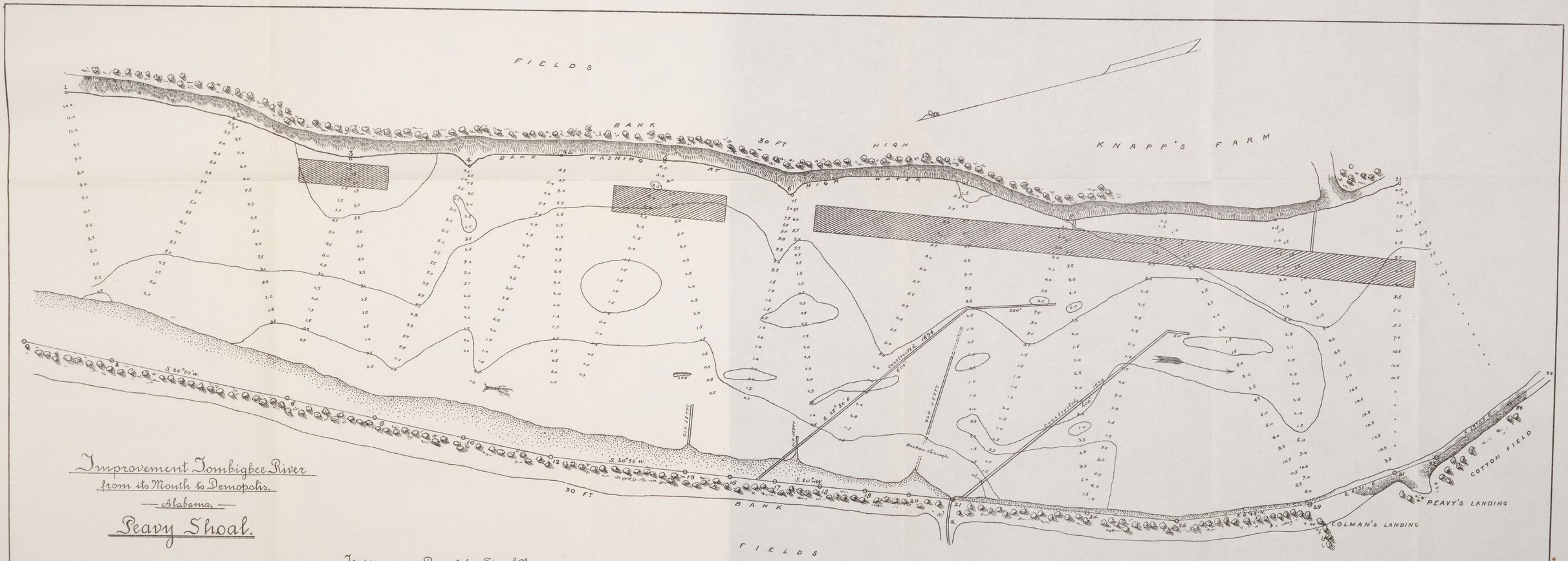
This annual output received and principally exported abroad is increasing largely since the deepening of Mobile Bay channel, which allows cargoes to be loaded at Mobile, Ala.

The following table shows commercial value of cotton and merchandise as well as freight revenue on the river for the fiscal year ending June 30, 1896:

Articles.	Number.	Value.	Freight.
Cotton:			
Down ..... bales..	31,300	$1,250,000	$23,475
Up ..... do....	1,700	68,000	1,275
Total	33,000	1,318,000	24,750
Merchandise:			
Down	.....	221,000	8,850
Up	.....	1,375,000	35,500
Total	.....	1,596,000	44,350
Cotton, total	.....	1,318,000	24,750
Merchandise, total	.....	1,596,000	44,350
Timber brought down	.....	178,500	.....
Total number of passengers	8,900	.....	12,250
Grand total	.....	3,092,500	69,100

The low-water loss on cotton as above mentioned amounts to 12,000 bales, valued at $480,000, and freight as $9,000, loss on merchandise value $350,000, and freight as $8,500. The losses on the two items are taken from the record of this past season, and I am informed they have been exceeded in earlier seasons.

There is little question but that with a safe, navigable river, when steamers can ply regularly, the commercial resources of the valley will largely increase.



Improvement Tombigbee River
from its Mouth to Demopolis.
— Alabama. —
Peavy Shoal.

Scale.

100' 0 200' 400' 600'

NOTE. The shaded portion was dredged in Aug & Sept 1894 to 6 feet.

The zero of Elevations at Peavy Shoal is (214) referred to Mobile datum.

To accompany Report for Fiscal Year ending June 30th. 1896.

Major of Engineers, U. S. A.

ANDREW B. GRAHAM, PHOTO-LITHO WASHINGTON, D.C.

It is intended during this low-water season to run lines of cross-sections near and above McGrew Shoal, as well as in the locality of Naheola Shoals, to fix accurately the succeeding high-water lines and upon which to calculate high-water discharge.

I have omitted to state that two sites of land have been acquired by purchase at McGrew, the one on left bank or lock side, 4.80 acres, the one on right bank or dam landing, 2.41 acres. Stone monuments mark our boundaries.

It is estimated that with the funds remaining over from fiscal year, added to that of recent appropriation for this stream, will cover the cost of completing lock and continuing temporary work of dredging and snagging. The final plans on McGrew dam have not been concluded nor estimates made on the next lock, near Naheola, but an approximate estimate of an additional $275,000 for the completion of the improvement will be safe.

Very respectfully, your obedient servant,

T. W. NICOL,
Assistant Engineer.

Maj. WM. T. ROSSELL,
Corps of Engineers, U. S. A.

(*c*) TOMBIGBEE RIVER FROM DEMOPOLIS TO COLUMBUS, MISS.

An appropriation for the survey of this section of the river was made in 1870, and report on same submitted to the Chief of Engineers April 17, 1871, published in Annual Report of the Chief of Engineers for 1871, page 573.

The project provided for removing obstructions and building wing dams, and was adopted in 1872.

At this time, and until 1880, the appropriations were made general for the Tombigbee River, but in the river and harbor act of this year this was changed, and one appropriation was first made specifically for a part of this section of the river, viz, from Columbus to Vienna.

The project was modified in 1879, the object being to afford a low-water channel of navigable width and 3 feet deep by removing obstructions, building wing dams, and closing island chutes. As the sections of this river appropriated for have changed, overlapping in many cases, it is not possible, except at considerable cost, to separate the amount expended on this stretch from the rest.

In the Report of the Chief of Engineers for 1888, part 2, page 1227, there is a preliminary report on survey of the Tombigbee River from its mouth to Vienna, and from Vienna to Walkers Bridge.

In the estimated cost of improvement of this stretch of river we find it here under two heads, viz, Demopolis to Vienna, and Vienna to Columbus.

The final report on this survey was submitted December 24, 1889, published in Annual Report of the Chief of Engineers for 1890, part 2, page 1719.

The project proposed removal of obstructions, snags, etc., and the building of dams with pneumatic gates, at a cost of $779,400. By these means it was proposed to a obtain a channel 6 feet deep at low water.

After this time Congress has appropriated separately for this portion of the river, its length being 156 miles.

The following appropriations have been made:

By act of—	
September 19, 1890	$15,000
July 13, 1892	35,000
August 17, 1894	50,000
June 3, 1896	50,000
Total	150,000

Under these appropriations work was commenced in June, 1891, and has been continued since whenever the stage of water permitted. The

work consisted in the removal of snags, logs, stumps, and overhanging trees, and repairs of jetties.

The entire section has now been once cleared of snags, and a large portion of it twice. The river is now navigable for boats at a 3½-foot rise above ordinary low water, but it will require an annual expenditure of $10,000 to keep it free from snags, logs, and overhanging trees, this being in addition to the amount necessary to carry out the original project.

The following is a statement of the total amount of work performed up to June 30, 1895:

Snags pulled, cut up, and removed		6,948
Stumps leveled, blasted, and removed		2,538
Logs on banks cut up		2,419
Sunken trees pulled, cut up, and removed		110
Overhanging trees felled, pulled back, cut up, and removed		16,520
Trees deadened		39
Trees trimmed		210
Bushes cut		19,433
Drift piles removed		4
Jetties built and repaired	linear feet	520

From July to December, 1895, one party on the quarter boat *Fulton* worked from near Moores Bluff down to Ballards Lake, where she met the snag boat *Pickensville* working from Jones Bluff upstream.

The river being too high to work to advantage both boats were carried downstream to Jones Bluff in December and laid up. During the same period the steamer *Sipsey* and the snag boat *Noxubee* worked from Greens Bar to Jones Bluff.

In January, 1896, work was suspended on account of high water and both the *Sipsey* and *Noxubee* were carried down to Mobile, Ala., for repairs and laid up.

During January, February, and March, 1896, the plant was repaired, and in May, 1896, operations were resumed. The snag boat *Noxubee* commenced work at the mouth and reworked the river up to a point about 3 miles above Jones Bluff, the principal work being snagging and tree cutting.

The following is a statement of work performed up to June 30, 1896:

Snags pulled, cut up, and removed		7,413
Stumps leveled, blasted, and removed		1,143
Logs on banks cut up		899
Overhanging trees felled, pulled back, cut up, and removed		2,858
Bushes cut		4,630
Trees trimmed		273
Sunken trees pulled, cut up, and removed		10
Drift piles removed		24
Rock removed	cubic yards	10
Jetties repaired	linear feet	300

The total amount expended on the improvement up to June 30, 1896, is $65,226.

Money statement.

July 1, 1895, balance unexpended	$59,143.62
Amount appropriated by act of June 3, 1896	50,000.00
	109,143.62
June 30, 1896, amount expended during fiscal year	24,369.62
July 1, 1896, balance unexpended	84,774.00
Amount (estimated) required for completion of existing project	629,400.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	200,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

COMMERCIAL STATISTICS.

Articles.	1896.	1895.	1894.
	Tons.	*Tons.*	*Tons.*
Cotton	2,062	3,500	2,400
Grain	1,105	2,508	2,663
Iron	20	31	54
Lumber	16,590	7,000	7,022
Merchandise	5,436	7,103	7,450
Total	23,213	20,142	19,569

(*d*) TOMBIGBEE RIVER FROM FULTON TO COLUMBUS.

A survey of this portion of the river was made under the act of June 10, 1872. Report thereon was submitted September 20, 1873.

The project adopted was to improve high-water navigation from Fulton to Columbus, a distance of 144 miles, by removal of all timber obstructions above low water, and to clear the banks of overhanging trees, at an estimated cost of $35,000, and $5,000 annually for preservation.

The original project was completed at a cost of $27,293.65.

The following appropriations have been made specifically for preservation of this section of the river:

By act of—	
July 13, 1892	$6,000
August 17, 1894	4,000
June 3, 1896	8,000
Total	18,000

The following is a statement of work performed up to June 30, 1895:

Stumps cut, leveled, and blasted	1,043
Snags cut and removed	160
Logs on banks cut up and removed	2,507
Overhanging trees felled, pulled back, cut up, and removed	7,345
Drift piles removed	58

The work has resulted in clearing the river of obstructions that had accumulated since the completion of the project from Fulton to the mouth of Old Town Creek, a distance of $74\frac{3}{4}$ miles.

During May, 1896, the quarter boat *Fulton* and snag boat *Pickensville* were ordered from Jones Bluff, Alabama, where they had been laid up during the winter, to the river above Columbus, the *Fulton* to work near the railroad bridge of the Kansas City, Memphis and Birmingham road, in order to close up Long Chicken Slough and Bolling Slough, through which the greater part of the rafts and timber were carried into the swamps and lost, the *Pickensville* to work from Old Town Creek up to the railroad bridge in similar work.

On June 1, 1896, preparations were made for closing Long Chicken Slough. A pile driver was constructed, 90 piles were cut and hauled, and the driving of piles commenced.

The closing of Long Chicken Slough was completed on June 22, 1896.

Work on closing Bolling Slough was commenced June 23, 1896.

The snag boat *Pickensville* left Jones Bluff on May 5, 1896, working upstream to Columbus. In going through a chute just above Columbus the boat got snagged and sunk, but was raised. The necessary repairs delayed her about nine days at Columbus. She is now on her way up to Old Town Creek.

The following is a statement of work performed during the fiscal year ending June 30, 1896:

Snags pulled, cut up, and removed	5
Stumps leveled, blasted, and removed	5
Logs pulled, cut up, and removed	2
Logs on banks cut up	9
Overhanging trees felled, pulled back, and removed	12
Piles cut and hauled	90
Piles driven for closing slough	36
Fascines made and sunk	291
Gravel and clay excavated, wheeled and filled in.....cubic yards..	1,080
Posts and braces cut	76

A bridge was constructed across a branch 15 feet wide, for hauling and wheeling gravel, brush, piling, braces, lumber, etc.

One hundred and eighty linear feet of old jetties was repaired.

The total amount expended up to June 30, 1895, was $5,929.47 in preservation of the improvement.

The total amount expended during the fiscal year ending June 30, 1896, was $733.97, in preservation of the improvement.

Money statement.

July 1, 1895, balance unexpended	$4,070.53
Amount appropriated by act of June 3, 1896	8,000.00
	12,070.53
June 30, 1896, amount expended during fiscal year	733.97
July1, 1896, balance unexpended	11,336.56
Amount that can be profitably expended in fiscal year ending June 30, 1898, for maintenance	5,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

(*e*) TOMBIGBEE RIVER FROM WALKERS BRIDGE TO FULTON.

An examination was made of this section of the river under act of March 3, 1881, and August 5, 1886.

The project adopted was the opening of a channel for high-water navigation from Fulton to Walkers Bridge by the removal of snags, logs, and overhanging trees, at an estimated cost of $11,000.

The following appropriations have been made:

By act of—	
August 11, 1888	$4,000
September 19, 1890	4,000
July 13, 1892 (maintenance)	3,000
August 17, 1894 (maintenance)	1,000
June 3, 1896 (maintenance)	1,000
Total	13,000

Under these appropriations work was commenced at Fulton, November, 1888, and continued at intervals up to June 30, 1891, and the project completed.

Work on the preservation of the improvement was commenced in September, 1892, and continued at intervals up to November, 1893. Since then no work has been done on this river.

The following is a statement of work performed up to June 30, 1896:

Trees felled, pulled back, and removed	6,692
Logs removed	1,085
Drift piles removed	17
Stumps leveled and removed	1,329
Snags cut and removed	258
Logs on banks cut up	590

The condition of this section of the river on June 30, 1896, is such as to allow large-sized rafts to be floated downstream on a 3-foot rise above ordinary low water.

The total amount expended on the improvement up to June 30, 1896, is $10,982.07, of which $3,390.96 was in preservation of the improvement.

Money statement.

July 1, 1895, balance unexpended	*$1,017.93
Amount appropriated by act of June 3, 1896	1,000.00
July 1, 1896, balance unexpended	2,017.93
Amount that can be profitably expended for maintenance in fiscal year ending June 30, 1898	1,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

Downstream.

Articles.	1896.		1895.		1894.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Saw logs	20,000	$400,000	30,000	$600,000	12,500	$250,000

P 4.

IMPROVEMENT OF NOXUBEE RIVER, MISSISSIPPI.

The examination of this river provided for by act of Congress approved March 3, 1879, was made during the month of May, 1880, and extended from Macon, Noxubee County, Miss., to the mouth of the river. Report thereon is contained in Annual Report of the Chief of Engineers for 1880.

The condition of the river when examined was such that during all seasons of the year and at all stages of water, navigation, except by small flatboats, was practically impossible. Prior to the building of the Mobile and Ohio Railroad (1859) steamboats plied the river. After the construction of this railroad the boats were withdrawn. The chief obstructions to navigation consisted in the immense number of trees overhanging the river throughout the entire length.

At the time of the examination the minimum depth of the river was found to be (at ordinary low water) 1½ feet and the average width 60 feet.

The project adopted was to afford a navigable channel during high water, or for about five months, to the town of Macon, by the removal of overhanging timber from the banks and such obstructions to navigation as might be found in the river. The estimated cost was $65,245.25.

*The amount reported in the Annual Report for 1895 was erroneous, and should have been $1,017.93.

The appropriations made for this improvement are as follows:

By act of—	
June 14, 1880	$12,000
March 3, 1881	8,000
August 2, 1882	10,000
July 5, 1884	7,500
August 5, 1886	7,500
August 11, 1888	5,000
September 19, 1890	3,000
September 13, 1892 (maintenance)	3,000
August 17, 1894 (maintenance)	3,000
June 3, 1896 (maintenance)	3,000
Total	62,000

Work was commenced on the river during the low-water season of 1880 and continued at intervals to October, 1889, and resulted in the completion of the project, at an estimated cost of $49,712.54.

Operations from November, 1889, to May, 1894, were confined to repairing and caring for the working plant and other public property.

At the beginning of the fiscal year ending June 30, 1895, work was in progress (having been begun May 1, 1894), removing such obstructions as had accumulated since the last previous work. This work was continued until December 30, 1894, when the mouth of the river was reached and work was suspended, the river having been again completely cleared.

The following is a summary of the work performed:

Overhanging trees felled and removed	4,520
Logs on banks cut up	2,615
Piles of drift removed	13
Snags and stumps removed	1,211

The river is now and has been since October, 1889, navigable at high water up to Macon, but it will require an expenditure of $3,000 every year or so to maintain it in its improved condition.

During the year 1889 one boat made several trips up the river, but was withdrawn, and no boats have since plied it, the railroads having lowered freight rates to such an extent as to keep all business away from the river. The value of the trade of Macon and vicinity is estimated at half million dollars annually in each direction, and the saving in freight, owing to the river being open, would be $20,000 each year.

The amount expended on the improvement of this river up to June 30, 1896, is $58,096.81. Of this amount $8,384.27 was in maintenance of the improvement.

Money statement.

July 1, 1895, balance unexpended	$903.19
Amount appropriated by act of June 3, 1896	3,000.00
July 1, 1896, balance unexpended	3,903.19
Amount that can be profitably expended for maintenance in fiscal year ending June 30, 1898	3,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

P 5.

IMPROVEMENT OF PASCAGOULA RIVER, MISSISSIPPI.

By act of—	
March 2, 1827, an appropriation was made of	$8,000
May 23, 1828, an appropriation was made of	17,500
August 30, 1852, an appropriation was made of	5,000

The first appropriation was made for removing obstructions from the river and deepening the channel at its mouth, the second one was made

for deepening the channel at its mouth, and the third one was made for a survey of the river. There are no records in this office of the work done under these appropriations.

In 1870, March 1, a canal (called Noyes Canal), dredged across the bar at the mouth of the river, under a charter from the State of Mississippi to Abram A. Green, to a depth sufficient to admit vessels of 6 feet draft at low tide, was opened by private parties.

The cost of the canal has been stated to be $27,000, and for annual maintenance, $4,000.

By the act of March 3, 1873, a survey was directed to be made at East Pascagoula Harbor, Mississippi Sound. This survey was made during the same year, and report was submitted October 23, 1873. The report is contained in the Annual Report of the Chief of Engineers for 1874. The plan adopted for the improvement was the dredging of a channel 200 feet wide and 7 feet deep at mean low water, through the bar at the mouth of the river, and the removal of snags and overhanging trees throughout its entire length, at an estimated cost of $53,800.

The following appropriations were made to carry out this project:

By act of—	
June 17, 1878	$10,000
March 3, 1879	14,000
June 14, 1880	20,000
March 3, 1881	4,000
August 2, 1882	8,000
July 5, 1884	3,000
Total	59,000

At the commencement of the work there was 3 feet on the crest of the bar at mean low water, and the river was much obstructed by snags, logs, and overhanging trees. Of the aggregate amount of the several appropriations made up to July 5, 1884, less $1,500 allotted for examination, $42,500 was devoted to dredging through the bar at the mouth, and resulted in securing a channel through the bar 180 feet to 190 feet wide, 7½ to 8 feet deep.

Fifteen thousand dollars of the amount appropriated up to that time was applied to the removal of snags, logs, and overhanging trees. Commencing at the light-house near the mouth of the river, in the spring of 1882, the work was prosecuted during the working seasons of 1882, 1883, and 1884.

This portion of the work was completed on December 23, 1893, and resulted in securing a navigable channel from the mouth of the river to one-half mile above Dead Lake, 50½ miles, for vessels drawing 6½ feet, and to the junction of the Leaf and Chickasahay for vessels of lighter draft, during six or eight months of the year. The project was then virtually completed.

By act of—	
August 5, 1886, an appropriation was made of	$20,000
August 5, 1886, transferred amount appropriated for improving Horn Island Pass, act of July 5, 1884	5,000
August 11, 1888, an appropriation was made of	27,000
September 19, 1890, an appropriation was made of	20,000
July 13, 1892, an appropriation was made of	20,000
August 17, 1894, an appropriation was made of	13,000
June 3, 1896, an appropriation was made of	6,000
Total	111,000

Under these appropriations a new project was proposed and approved for securing a channel of navigable width and minimum depth of 12 feet from Moss Point to the anchorage in the Mississippi Sound, by

dredging and construction of dam at Lowery Island, under contract, at an estimated cost of $78,100, and maintaining the river above Moss Point in its improved condition by day labor, at an annual cost of $2,500.

Statement of work done under the above appropriations.

Date of act.	Name of contractor.	Contract price measured in scow.	Cubic yards removed.	Commenced.	Completed.
		Cents.			
Aug. 5, 1886	J. H. Gardner	18.4	113,529	Oct. 8, 1887	Apr. 28, 1888
Aug. 11, 1888	Geo. C. Fobes & Co	16.2	73,619	Apr. 16, 1890	July 30, 1890
Do	Alabama Dredging and Jetty Co.*				
Sept. 19, 1890	do	22	86,598	Feb. 14, 1891	Sept. 25, 1891
July 13, 1892	do	18	99,977	Oct. 12, 1892	Dec. 19, 1892

Date of act.	Name of contractor.	Plant.		
		Apparatus.	Capacity of bucket.	Capacity of scow and character of material.
Aug. 5, 1886	J. H. Gardner	1 scoop dredge, 1 clam-shell dredge, 4 scows, 2 tugs.	2 cubic yards; 4 cubic yards.	70, 71, 274, and 441 cubic yards. Hard clay, sand, and little mud.
Aug. 11, 1888	Geo. C. Fobes & Co	1 clam-shell dredge, 2 scows, 2 tugs.	3½ cubic yards	320 and 334 cubic yards. Compact sand and little mud.
Sept. 19, 1890	Alabama Dredging and Jetty Co.	1 scoop dredge, 1 clam-shell dredge, 4 scows, 2 tugs.	2 cubic yards; 4 cubic yards.	143, 159, 323, and 489 cubic yards. Clay, little sand, and black mud.
July 13, 1892	do	2 clam-shell dredges, 4 scows, 2 tugs.	4 cubic yards; 4½ cubic yards.	274, 318, 441, and 489 cubic yards. Clay and compact sand.

* Submerged dam at Lowery Island, 270 linear feet, with wings (riprap), commenced May 1, 1890, and completed July 16, 1890, at a cost of $3,350.

In the river above Moss Point the following work was done by day labor to June 30, 1895:

Snags pulled, blasted, and removed	1,972
Sunken logs and trees felled and removed	633
Logs on banks cut up	440
Overhanging trees felled, pulled back, and cut up	5,150
Stumps blasted, leveled, and removed	242
Stumps removed from river	82
Trees trimmed	20
Bushes cut	3,500

The following is a statement of the work performed during the fiscal year ending June 30, 1896:

Snags pulled, cut up, and removed	437
Stumps leveled, blasted, and removed	43
Logs on banks cut up	37
Overhanging trees felled, pulled back, and removed	1,524
Trees trimmed	32

The extent and condition of the work was as follows June 30, 1894:

Extent.	Condition.
I. Snagging and cutting overhanging trees from the head to the mouth.	Completed from Moss Point to Wilkinson Ferry; partially improved from Wilkinson Ferry to head.
II. Dredging channel from Moss Point to mouth, of navigable width and 12 feet depth, and construction of dam at Lowery Island.	Complete to width of 80 feet and in good condition when last examined. Dam completed.
III. Dredging channel of navigable width and 12 feet deep from the mouth to the 12-foot curve in Mississippi Sound; length of 18,898 feet.	Completed to a width of 80 feet for a distance of 6,112 feet, and to a width of 120 feet for a distance of 3,960 feet.

During the fiscal year ending June 30, 1896, $578.06 was expended in making a preliminary examination of a troublesome shoal in Horn Island Pass, located northeast of the eastern spit of Horn Island, and threatening the main entrance of the port of Pascagoula.

Total amount expended on the improvement up to June 30, 1896, is $97,172.21, of which $10,237.49 was in preservation of improvement.

The original cost of the approved project was estimated at $78,000, but owing to the extreme hardness of a portion of the bottom to be dredged and the smallness of the appropriations made available, the cost of excavation proved to be in excess of that originally estimated.

The new survey made in June, 1887, called for an expenditure of $129,120.14 for the dredging of a 12-foot channel of navigable width through East Pascagoula River, from the mills at Moss Point to the anchorage of Pascagoula Bay, Mississippi.

Money statement.

July 1, 1895, balance unexpended	$10,954.66
Amount appropriated by act of June 3, 1896	6,000.00
	16,954.66
June 30, 1896, amount expended during fiscal year	3,126.87
July 1, 1896, balance unexpended	13,827.79
Amount (estimated) required for completion of existing project	42,185.42
Amount that can be profitably expended in fiscal year ending June 30, 1898	10,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

COMMERCIAL STATISTICS.

Manufacturing industries located at Pascagoula, Miss., and vicinity: 18 saw mills, daily capacity 865,000 superficial feet; 6 planing mills, daily capacity 141,000 feet; 1 creosote works, daily capacity 22,000 superficial feet; 8 marine ways, yearly payments in wages $23,000; 1 ice plant, daily capacity 20,000 pounds.

Comparative statement tabulated from information furnished by the United States custom-house for Pascagoula Harbor.

Vessels cleared.	1896.		1895.	
	Number.	Tons.	Number.	Tons.
Foreign	175	98,712	119	93,390
Domestic	41	16,610	144	40,355
Via Ship Island	.....	42,796	.....	.....
Total	216	158,118	263	133,745

Coastwise shipments in 1896 not included in United States custom-house statement.

Articles.	Tons.	Value.
Lumber and timber	10,894	$66,626
Creosoted timber	1,190	23,801
Creosoted piles	2,570	43,767
Rosin	3,000	45,000
Turpentine	600	45,000
Charcoal	4,438	35,500
Wool	13	3,000
Packing cases	180	640
Fruit and vegetable boxes	4	240
Total	22,889	263,574

Coastwise shipments in 1896 not included in United States custom-house statement—Cont'd.

Articles.	Tons.	Value.
Downstream:		
Saw logs	22,105	$79,580
Rosin	2,000	40,000
Turpentine	400	24,000
Wool	10	6,000
Shingles	8	40
Cord wood	250	4,000
Total	24,773	153,620

P 6.

IMPROVEMENT OF CHICKASAHAY RIVER, MISSISSIPPI.

The act of Congress of August 11, 1888, provided for an examination of Chickasahay River, Mississippi, from its mouth to Enterprise, and report thereon was submitted on February 16, 1889.

The approved project was to clear the channel from its mouth to the railroad bridge near Shubuta, Miss., by removal of snags, logs, and overhanging trees, at an estimated cost of $30,000.

The following appropriations have been made:

By act of—	
September 19, 1890	$5,000
July 13, 1892	5,000
August 17, 1894	5,000
June 3, 1896	2,000
Total	17,000

Under these appropriations work was commenced on October 13, 1891, and continued at intervals until January, 1896.

The following is a statement of the total work performed up to June 30, 1895:

Snags cut, trimmed, blasted, and removed		11,716
Stumps leveled, blasted, and removed		1,135
Overhanging trees felled, pulled back, cut, and removed		8,583
Trees trimmed		5,832
Logs on bank cut up		15,189
Bushes cut		12,180
Rock blasted and excavated	cubic yards	28
Clay excavated and removed	do	12

The following is a statement of the work performed during the fiscal year ending June 30, 1896:

Snags cut, trimmed, blasted, and removed	3,120
Stumps leveled, blasted, and removed	640
Logs on bank cut up	3,400
Overhanging trees cut, felled, pulled back, and removed	2,781

The work has resulted in giving a much better high-water channel from Waynesboro to the mouth, allowing small steamboats to run on a 4-foot rise above low water as far as the Mobile and Ohio Railroad Bridge, near Buckatunna, Miss., and larger rafts of logs and timber to be brought down from and above Waynesboro.

Eighty-five miles of river from the mouth up to Winchester Rocks has been reworked, removing the annual accumulation of obstructions.

It is the opinion of the principal business, timber, and log men of Wayne County, Miss., that all that the present commerce requires is

the improvement of the river from the mouth up to the Mobile and Ohio Railroad Bridge near Buckatunna for light-draft steamers during six or eight months of the year, and that the river above the bridge be improved only for rafting and logging.

This, it is claimed, would satisfy all parties having interests on the river.

It is stated that a very small steamer made only one trip above the bridge, and then only to Waynesboro, during the year.

All the freights for the different towns along the river is hauled by the Mobile and Ohio Railroad, which runs almost parallel with the river, and within easy reach, to Enterprise, Miss., which is considered the head of navigation.

The total amount expended on the improvement up to June 30, 1896, is $13,466.92, of which $1,117.19 was in preservation of the improvement.

Money statement.

July 1, 1895, balance unexpended	$4,711.46
Amount appropriated by act of June 3, 1896	2,000.00
	6,711.46
June 30, 1896, amount expended during fiscal year	3,178.38
July 1, 1896, balance unexpended	3,533.08
Amount (estimated) required for completion of existing project	13,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	2,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

P 7.

IMPROVEMENT OF LEAF RIVER, MISSISSIPPI.

The act of Congress of August 11, 1888, provided for an examination of Leaf River from its mouth to the mouth of Bowie Creek, near New Orleans and Northeastern Railroad, and report thereon was submitted February 15, 1889.

The approved project was to clear a channel from its mouth to Bowie Creek for high-water navigation by the removal of snags, logs, and overhanging trees, 75 miles, at an estimated cost of $25,000.

The following appropriations have been made:

By act of—	
September 19, 1890	$5,000
July 13, 1892	5,000
August 17, 1894	2,500
June 3, 1896	2,500
Total	15,000

Under these appropriations work commenced during August, 1891, and continued at intervals up to December 23, 1893. Since then no work has been done on the river.

The following is a statement of the total work performed up to June 30, 1896:

Snags pulled, cut up, and trimmed	2,081
Sunken logs and trees removed	110
Overhanging trees felled, pulled back, cut up, and removed	5,804
Logs on bank cut up	2,691
Stumps leveled, blasted, and removed	5,412
Trees trimmed	1,351
Bushes cut and removed	1,760
Drift piles removed	53

This work has resulted in giving a high-water channel from Bowie Creek to the mouth, a distance of 75 miles, of which 60 miles, from the mouth up to Choctaw Bluff, has been improved according to the project, and 15 miles, from Choctaw Bluff to Bowie Creek, was only partially improved and requires reworking.

The total amount expended on the improvement of this river up to June 30, 1896, is $9,676.40, of which $3,084.28 was in preservation of the improvement.

Money statement.

July 1, 1895, balance unexpended	$3,090.66
Amount appropriated by act of June 3, 1896	2,500.00
	5,590.66
June 30, 1896, amount expended during fiscal year	267.06
July 1, 1896, balance unexpended	5,323.60
Amount (estimated) required for completion of existing project	10,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	5,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

COMMERCIAL STATISTICS.

Downstream.

Articles.	1896.		1895.		1894.	
	Tons.	Value.	Tons	Value.	Tons.	Value.
Saw logs (hewn timber, sawed timber) ..	62,625	$313,000	90,000	$500,000	50,000	$45,000
Lumber	.....	.....	25,000	20,000	20,000	15,000
Total	62,625	313,000	115,000	520,000	70,000	60,000

One small stern-wheel steamer made only one trip up this river.

A small river steamer is now being constructed at Hemphill's sawmill, about 40 miles below Hattiesburg, to be used on this river next winter.

P 8.

IMPROVEMENT OF PEARL RIVER BELOW JACKSON, MISSISSIPPI.

The original project for improving this section of the river was adopted in 1880, the object being to obtain a navigable channel 5 feet deep at low water from Jackson down to the mouth, a distance of 312 miles, by the removal of snags, stumps, roots, logs, and trees, and closing run-out bayous, at an estimated cost of $95,940, based upon the report of a survey made during March and April, 1879.

Upon an examination made at low water in December, 1884, it was found that a 5-foot channel at low water was not practicable by the method proposed, but that a 2-foot channel at low water could be obtained in that manner, and was all that the present commerce of the river required.

Owing to the large amount of obstructions found during that examination, the river being at a considerably lower stage than during the survey in 1879, the original estimate was increased $50,000, making it $145,940.

In addition to the improvement of the river proper, the increased lumber trade of the mills situated on East Pearl River demands the dredging of the channel over the bar at the mouth of East Pearl River to 12 feet, a rough estimate of the cost of which is $20,000.

Forty-five miles above the mouth, at the Rigolets, this river divides into what is known as East and West Pearl rivers.

West Pearl River turns off in a southwest direction, and runs, for a distance of about 20 miles, through a dense cypress swamp and over several rock shoals; navigation here is impossible.

The main river, or East Pearl River, used for navigation, continues to flow in a southerly direction down Holmes Bayou, where it turns off to the southeast; but Holmes Bayou having the best channel, and the entrance being in line with the river above, the greater portion of water enters the bayou.

Seven miles below the head of the bayou, at its mouth, West Pearl River, which runs off to the southwest 20 miles above, again joins the river, adding about two-thirds water to it. From there down the river is called West Pearl.

On account of so much water being carried off by West Pearl, although it returns 20 miles below, considerable shoaling took place and sand bars formed all the way down to the mouth of Holmes Bayou.

In order to relieve navigation a cut-off was opened in 1885, about 2 miles above the head of West Pearl River, through a narrow strip of land 1,200 feet wide. The cut was made 100 feet wide and about 1 foot below low-water mark and soon widened and deepened, and is now from 250 to 300 feet wide and 6 feet deep at low water, through which the greater part of water from above now flows. Steamboats and rafts are now using this cut-off.

The portion of the river between the cut-off and the head of West Pearl River commenced to fill up, willows took hold, and it is expected that it will finally close up altogether.

Before the war this river could be navigated only during very high water. Holmes Bayou, about 7 miles long, and then only about 40 feet wide, was the most troublesome part of it.

Shortly before the war the States of Louisiana and Mississippi jointly appropriated $10,000 for cleaning out Holmes Bayou, which was done. During the war the Confederates, fearing that the Federal gunboats would ascend the river to Jackson, Miss., closed this bayou by cutting all the large trees from the banks across the bayou. This left navigation almost impossible except during very high water.

During 1886 and 1887 Holmes Bayou was thoroughly cleaned out by hired labor, and widened to 100 feet, making it navigable for light-draft boats at a 2-foot rise above ordinary low water.

This river from the mouth at the Rigolets up, for about 25 miles, is from 8 to 15 feet deep, and is navigated by towboats, schooners, lighters, etc., engaged in the lumber, firewood, charcoal, and general merchandise trade.

From there up to Monticello, Miss., 185 miles, 2 feet of water can be carried nearly all the year, and is used by river steamers, carrying cotton, produce, fertilizers, grain, etc., and by rafts of logs and timber. From Monticello up to Jackson, 102 miles, navigation is possible only on a 7-foot rise above ordinary low water, and is dangerous even then.

Boats do not go higher than Monticello. There is no commerce on this section.

This section of the river was improved in 1885 by contract.

The portion of the river turning off at the head of Holmes Bayou in a southeast direction, and known as East Pearl River, is not, and never has been, navigable for boats from the head down. Loose logs are being driven down to the mills at and near its mouth, but only during 6 or 8 foot rise. The river being nearly filled up with logs, rafts, and drift, willows and cottonwood have taken possession, and scarcely any

water passes through at a less stage than 6 feet. About 20 miles below the head, several sloughs and creeks supply enough water for rafting purposes down to the mills at Gainesville, Logtown, and Pearlington. From these mills down to the mouth near English Lookout, into Mississippi Sound, towboats, schooners, and lighters are engaged in the lumber trade and carrying business of the mills.

Over the bar at the mouth ot East Pearl River 7½ feet can be carried at mean low tide. Vessels can be loaded down to 12 feet at the mills; the owners desire to obtain that depth over the bar at mean low tide.

The cost of deepening the bar by dredging to 12 feet was estimated at $20,000. Ten thousand dollars is now available for that purpose.

Bids for dredging were solicited January, 1893, and opened in March, 1895, but were rejected, the prices bid being considered too high. Nothing has been done since.

The following appropriations have been made:

By act of—		By act of—	
June 14, 1880	$30,000	September 19, 1890	$20,000
March 3, 1881	25,000	July 13, 1892	15,000
August 2, 1882	15,000	August 17, 1894	5,000
July 3, 1884	10,000	June 3, 1896	10,000
August 5, 1886	13,125		
August 11, 1888	15,000	Total	158,125

Under these appropriations (except that of June 3, 1896) work was commenced in December, 1880, and continued at intervals up to September, 1895. From December, 1880, to August, 1882, the work done was by contract, and 295 miles of river, from Jackson down, were partially improved. In November, 1882, work by hired labor was commenced, and has been continued ever since.

One hundred and sixty and three-fourths miles of river, from the mouth to Cannons Creek, Mississippi, were improved by hired labor, according to project, the balance up to Jackson, Miss., 151¼ miles, was partially improved by contract.

The following is a statement of work performed up to June 30, 1895:

Snags pulled, cut up, and removed		9,218
Roots removed and blasted		6,808
Sunken logs pulled and removed		5,372
Stumps leveled, blasted, and removed		2,438
Knees removed		87
Standing trees felled, cut up, and removed		1,693
Overhanging trees felled, cut up, and removed		43,670
Logs on banks cut up		417
Trees deadened		2,936
Trees trimmed		104
Bushes cut		2,310
Drift piles removed		123
Sand and clay excavated and removed	cubic yards	11,889½
Cane cut and removed	running yards	9,422
Piles for jetties driven		256
Willows planted for jetties	cords	636
Trees felled, moved, and sunk for jetties		1,531
Sunken logs and trees pulled for jetties		116
Willows cut and made into mattresses	cords	618
Clay excavated, transported, and sunk for jetties	cubic yards	3,220

The following is a statement of work performed during the fiscal year ending June 30, 1896:

Snags pulled, cut, and removed		209
Drift piles removed		3
Overhanging trees felled, pulled back, cut, and removed		277
Trees trimmed		102
Bushes cut		515
Clay excavated and removed	cubic yards	100
Sand excavated and removed	do	100

The condition of the river on June 30, 1896, is such as to allow light-draft boats to navigate from the mouth to Cannons Creek, a distance of 160¾ miles, all the year.

From Cannons Creek to Monticello, although the river has been only partially improved by contract and no work by hired labor has yet been done there, is in fair condition, and light-draft boats can go there all the year. From Monticello to Jackson, 150¼ miles, the river has only been partially improved by contract, and navigation is possible only on a 7-foot rise above low water.

The reduction in freights and insurance due to river improvement is considerable.

The total amount expended on the improvement up to June 30, 1896, is $138,179.65, of which $35,192.32 was in preservation of the improvement.

Money statement.

July 1, 1895, balance unexpended	$11,977.69
Amount appropriated by act of June 3, 1896	10,000.00
	21,977.69
June 30, 1896, amount expended during fiscal year	2,032.34
July 1, 1896, balance unexpended	19,945.35
Amount (estimated) required for completion of existing project	40,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	10,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

P 9.

IMPROVEMENT OF PEARL RIVER BETWEEN CARTHAGE AND JACKSON, MISSISSIPPI.

The original project was to afford a clear channel of navigable width and 5 feet deep at low water from Carthage to Jackson, a distance of 105 miles, at an estimated cost of $21,000.

In 1886 the depth to be obtained was reduced to 2 feet, and the estimate was increased $29,000, making the total estimate $50,000.

The original condition of this portion of the river was such as to permit navigation only during high water, and even then it was difficult and dangerous.

An examination of this part of the river was made in 1879, and report thereon is contained in the Annual Report of the Chief of Engineers of 1879 (Appendix K 2).

The following appropriations have been made:

By act of—		By act of—	
March 3, 1879	$6,000	September 19, 1890	$3,000
June 14, 1880	7,500	July 13, 1892	5,000
March 3, 1881	2,500	August 17, 1894	2,400
August 2, 1882	2,500	June 3, 1896	2,400
August 6, 1886	2,250		
August 11, 1888	2,500	Total	36,050

Under these appropriations work was commenced November 20, 1879, and continued at intervals up to the end of June, 1895.

The following is a statement of the total amount of work performed up to June 30, 1895:

Snags cut, trimmed, and removed	79,995
Stumps cut, leveled, and blasted	4,196
Logs on bank cut up	10,338
Sunken logs cut up and removed	5,184
Sunken trees cut up and removed	793
Drift piles removed	64
Overhanging trees felled, pulled back, and removed	17,936
Trees trimmed	2,655
Bushes cut	45,076

The following is a statement of work performed during the fiscal year ending June 30, 1896:

Snags cut up, leveled, blasted, and removed	1,066
Stumps cut up, leveled, blasted, and removed	175
Drift piles removed	3
Logs on banks cut up	480
Overhanging trees felled, pulled back, cut up, and removed	956
Trees trimmed	111
Bushes cut	4,300

The project is completed. The work to be done hereafter with the new appropriation will be for preservation of the improvement.

The condition of this section of Pearl River on June 30, 1896, is such as to allow light-draft boats to navigate safely on a 3-foot rise above ordinary low water from Carthage down to Jackson.

The total amount expended on the improvement of this section of the river up to June 30, 1896, is $33,650, of which $8,634.66 was for preservation of the improvement.

The reduction in freight and insurance due to river improvement is considerable.

Money statement.

July 1, 1895, balance unexpended	$704.18
Amount appropriated by act of June 3, 1896	2,400.00
	3,104.18
June 30, 1896, amount expended during fiscal year	704.18
July 1, 1896, balance unexpended	2,400.00
Amount that can be profitably expended for maintenance in fiscal year ending June 30, 1898	2,400.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

Vessels engaged on the river.

Class.	1896.			1895.		
	Length.	Draft.	Tonnage.	Length.	Draft.	Tonnage.
	Feet.	*Feet.*		*Feet.*	*Feet.*	
One stern-wheel steamboat	110	3	90	110	3	90
One propeller steamboat	40	3	50	40	3	50
Six flatboats	50	1½	250	50	1½	250

Articles.	1896.		1895.		1894.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Upstream:						
Merchandise, grain and fertilizers	350	$13,800	1,750	$118,000	1,320	$101,500
Downstream:						
Cotton, lumber, staves, wool, etc	570	38,760	3,678	150,950	3,043	108,150

P 10.

IMPROVEMENT OF PEARL RIVER, MISSISSIPPI, BETWEEN EDINBURG AND CARTHAGE.

A survey of this part of the Pearl River was made during November, 1883, and report thereon is contained in the Annual Report of the Chief of Engineers of 1884 (Appendix Q 18).

The original project was to afford a high-water channel from Edinburg to Carthage, a distance of 24¾ miles, for six or eight months of the year, at an estimated cost of $13,464.

The following appropriations have been made:

By act of—	
July 5, 1884	$2,500
August 5, 1886	2,250
August 11, 1888	5,000
September 19, 1890	5,000
July 13, 1892, maintenance	500
August 17, 1894, maintenance	500
June 3, 1896, maintenance	500
Total	16,250

Under these appropriations work was commenced on November 17, 1884, and continued at intervals up to September, 1895.

The following is a statement of the total work performed up to June 30, 1895:

Snags, stumps, logs, and trees cut up and trimmed		157,909
Standing trees cut and removed		368
Stumps blasted and removed		1,257
Logs on bank cut up		1,637
Fallen trees removed		94
Overhanging trees felled, pulled back, and removed		21,701
Trees trimmed		1,236
Bushes cut		50,115
Bank cleared of brush	yards	6,491
Drift piles removed		40

The following is a statement of work performed during the fiscal year ending June 30, 1896:

Snags cut, leveled, blasted, and removed	3,232
Stumps cut, leveled, blasted, and removed	430
Drift piles removed	2
Logs on bank cut up	809
Overhanging trees felled, pulled back, and removed	740
Trees trimmed	84
Bushes cut	2,550

The condition of this portion of the river on June 30, 1896, is such as to allow light-draft boats to navigate safely from Edinburg to Carthage on a 4-foot rise above ordinary low water.

The project is completed; the work to be done under the new appropriation of $500 will be in preservation of the improvement.

The reduction in freight and insurance due to river improvement has been considerable, but as the small stern-wheel steamer formerly running on this river has been taken off there seems to be no commerce whatever.

The total amount expended on the improvement of this river up to June 30, 1896, is $15,750 of which $5,087.51 was in preservation of the improvement.

Money statement.

July 1, 1895, balance unexpended	$1,008.65
Amount appropriated by act of June 3, 1896	500.00
	1,508.65
June 30, 1896, amount expended during fiscal year	1,008.65
July 1, 1896, balance unexpended	500.00
Amount that can be profitably expended for maintenance in fiscal year ending June 30, 1898	500.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

P 11.

IMPROVEMENT OF BOGUE CHITTO, LOUISIANA.

An examination of this river was made by direction of act of Congress of August 11, 1888, and report thereon submitted June 24, 1889.

The original project was to close the west mouth and to remove snags, logs, overhanging trees, and fish traps from the east mouth up to Alford Bridge, a distance of 190 miles, so that the river could be used by small river steamers the greater part of the year, at an estimated cost of $55,000.

The following appropriations have been made:

By act of—	
September 19, 1890	$5,000
July 13, 1892	5,000
August 17, 1894	5,000
June 3, 1896	5,000
Total	20,000

Under these appropriations work was commenced in August, 1893, and continued at intervals up to September, 1895.

The following is a statement of the total work performed up to June 30, 1895:

Snags pulled and removed		4,130
Stumps cut, leveled, and blasted		278
Logs on banks cut up		82
Overhanging trees felled, pulled back, and removed		8,603
Bushes cut		8,431
Drift piles removed		25
Sand removed at east mouth	cubic yards	156
Willow mattresses made and sunk		1,162
Piles cut for jetties and driven		59
Brush cut for jetties	cords	200
Clay and sand dug and wheeled to jetties	cubic yards	3,623

The following is a statement of work performed during the fiscal year ending June 30, 1896:

Snags pulled, cut up, and removed		1,213
Stumps leveled, blasted, and removed		103
Drift piles removed		20
Logs on banks cut up		161
Overhanging trees felled, pulled back, cut up, and removed		2,194
Bushes cut		2,675
Banks protected (brush)	linear feet	300

The work done has resulted in giving a 3-foot channel, according to project, from the east mouth up to Purvis Lake, a distance of 36 miles. The sand bars at the mouth have been removed; the river for a distance

of 1¼ miles from the mouth up has been widened from 20 to 45 feet and deepened to 3 feet, so as to allow light-draft boats and rafts of logs and timber to pass through at a slight rise above ordinary low water. The west mouth has been partially closed.

The total amount expended on the improvement up to June 30, 1896, is $14,983.21, of which $564.60 was in preservation of the improvement.

Money statement.

July 1, 1895, balance unexpended	$3,746.59
Amount appropriated by act of June 3, 1896	5,000.00
	8,746.59
June 30, 1896, amount expended during fiscal year	3,729.80
July 1, 1896, balance unexpended	5,016.79
Amount (estimated) required for completion of existing project	35,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	10,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

COMMERCIAL STATISTICS.

Articles.	1896.		1895.		1894.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
UPSTREAM.						
General merchandise	.....	.....	40	$18,000	.....	.....
Fertilizers	.....	.....	50	2,500	.....	.....
Total	.....	.....	90	20,500	.....	.....
DOWNSTREAM.						
Cotton	.....	.....	200	5,000	.....	.....
Rosin and turpentine	.....	.....	100	2,000	.....	.....
Hewn timber	.....	.....	10,000	75,000	5,600	$55,000
Saw logs, pine	6,750	$26,000	12,000	75,000	9,000	55,000
Saw logs, cypress	.....	.....	9,000	35,000	6,000	25,000
Total	6,750	26,000	31,300	192,000	20,600	135,000

The steamboat engaged on this stream in 1895 has been sunk and never raised.

P 12.

SURVEY OF BLACK WARRIOR RIVER, ALABAMA, FROM DANIELS CREEK TO THE MULBERRY AND LOCUST FORK.

[Printed in House Doc. No. 259, Fifty-fourth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., February 18, 1896.

SIR: The river and harbor act of August 17, 1894, provides, in the item making appropriation for the improvement of Black Warrior River, Alabama, from Tuscaloosa to Daniels Creek, that "the Secretary of War shall cause a survey of said river to be made for its further improvement to the Mulberry and Locust Fork, in harmony as to width and depth of channel with the work now being done between Tuscaloosa and Daniels Creek," and I have now the honor to submit the

accompanying copy of report, dated January 30, 1896, with map* and profile,* by Maj. William T. Rossell, Corps of Engineers, upon the subject.

The present project for improvement between Tuscaloosa and Daniels Creek provides for making the river navigable, by means of locks and dams, for barges of 6 feet draft.

To obtain the improvement desired between Daniels Creek and the Mulberry and Locust Fork, Major Rossell estimates that eight locks and dams, with an average lift of about 10 feet, would be required, at a cost of $1,750,000.

In this connection Major Rossell states that the most serious obstruction in this stretch of the river is Squaw Shoals, and that it may be necessary to construct a canal around them. It is his opinion that the necessity for the canal can only be determined after the taking of flood observations at and above the shoals, and to estimate the cost of such canal borings to determine the character of the material to be excavated would have to be made.

Very respectfully, your obedient servant,

A. MACKENZIE,
Acting Chief of Engineers.

Hon. DANIEL S. LAMONT,
Secretary of War.

REPORT OF CAPT. WILLIAM T. ROSSELL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., January 30, 1896.

GENERAL: The river and harbor act of 1894 requires:

Improving Black Warrior River, Alabama, from Tuscaloosa to Daniels Creek: Continuing improvement, thirty-seven thousand five hundred dollars; and the Secretary of War shall cause a survey of said river to be made for its further improvement to the Mulberry and Locust Fork, in harmony as to width and depth of channel with the work now being done between Tuscaloosa and Daniels Creek, and the expense of said survey shall be paid out of this appropriation.

The present project is to make the river navigable, by means of locks and dams, for barges of 6 feet draft, from Tuscaloosa to Daniels Creek. An examination and partial survey of the river from Tuscaloosa to Locust Fork, a distance of 47 miles, was made in 1874. (See Report of Chief of Engineers, 1875, pt. 2, p. 16.)

A survey of the river from Tuscaloosa to forks of the Sipsey and Mulberry, a distance of 92¼ miles, was made in 1879. (See Report of Chief of Engineers, 1881, pt. 2, p. 1218.)

During the autumn of 1895 the survey called for by the river and harbor act of 1894, was made, and I have the honor to forward herewith two blue prints† showing the results, and a tracing giving the profile of the river.

This stretch of river is a series of pools or lakes varying in width from 500 to 700 feet, skirted by rocky bluffs rising in some places 200 feet above the water.

These lakes are connected by rapids and falls.

The total fall from Locust Fork to Daniels Creek is 82.6 feet divided among seven shoals. The bottom is rocky, and it is believed that there

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* Omitted; printed in House Doc. No. 259, Fifty-fourth Congress, first session.
† One not printed.

will be no difficulties in foundations. While the exact location and lift for each lock should be left until the work is to be undertaken, I estimate that eight locks and dams, with an average lift but little more than 10 feet each, will give the desired improvement.

Experience gained in building the three locks and dams at and near Tuscaloosa shows that they can be built for not to exceed $200,000 each.

Hence the cost, allowing $150,000 for contingencies, supervision, etc., of the improvement, will be—

Eight locks and dams, at $200,000	$1,600,000
Contingencies, engineering expenses, etc	150,000
Total	1,750,000

Squaw Shoals, 25 miles above Tuscaloosa, is the most serious obstruction in this stretch of the river. This shoal is a series of rapids nearly 4½ miles long, and with a total fall of 41 feet.

It may be necessary to put in a canal around these shoals.

This can only be determined by flood observations at and above these shoals.

To estimate the cost of such a canal it will be necessary to make borings to determine the character of the material to be excavated.

Very respectfully, your obedient servant,

WM. T. ROSSELL,
Captain, Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

P 13.

SURVEY OF MOBILE HARBOR, ALABAMA.

[Printed in House Doc. No. 199, Fifty-fourth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., January 30, 1896.

SIR: The river and harbor act of August 17, 1894, provides that the Secretary of War shall cause a survey to be made to ascertain the cost of widening the channel of Mobile Harbor, Alabama, now in course of improvement, to obtain a width of 100 feet at the bottom, with a proper slope for the sides of such a channel, and I have now the honor to submit the accompanying copy of a report, dated the 16th instant, by Capt. Wm. T. Rossell, Corps of Engineers, upon the subject.

The existing project for the improvement of Mobile Harbor was adopted by Congress in 1888, the object being to provide a channel from the Gulf of Mexico to the city of Mobile 280 feet wide at top of cut with a central depth of 23 feet. The work was subsequently extended by Congress up Mobile River to the mouth of Chickasabogue Creek. The estimated cost of this work was $2,043,800, with a further expenditure of $60,000 for maintenance after June 30, 1891.

There has been appropriated for work under the existing project $1,993,800, and the law provided that the channel as projected should be completed for this sum. In October last the appropriation was exhausted and the projected channel virtually completed, as evidenced by the passage through it of vessels drawing 23 feet. Meantime there

was no appropriation for maintenance, though much work of that kind has been done.

The channel thus constructed is for its entire length of nearly 33 miles through material much of which is liable to be easily moved about and brought into the cut by the winds and waves; and such channel, as was contemplated by the project, can be maintained only by constant dredging.

It was thought the channel, with surface width of 280 feet and central depth of 23 feet, if properly maintained would be of sufficient capacity for commerce and navigation; but, now that the passage of the deeper draft vessels has been made possible, experience indicates that a wider channel is desirable, and is now demanded by the interests involved.

Captain Rossell estimates that the cost of widening and deepening the cut to give a bottom width of 100 feet and proper side slopes (which should be quite flat in order to give greater stability) will cost $1,640,000, and to maintain such channel will cost approximately $60,000 per year. His estimate is based on the actual amount of material to be removed as indicated by the latest maps showing the condition of the channel. The work proposed is the dredging of additional cuts nearly 33 miles long through the mud bottom of Mobile Bay, and the depths and widths to which dredging must be carried to guarantee a depth of 23 feet and a bottom width of 100 feet, as well as the cost of the work, can only be approximated. Some of the material is so soft that to obtain a depth of 23 feet requires dredging several feet deeper. The estimate for annual maintenance must also be considered as approximate, it being impracticable to determine, with present limited experience after the completion of the channel, how much dredging will be required for removing material brought into the cut and for preserving the dimensions of the proposed channel when once completed.

The improvement of the harbor of Mobile has been progressive. First, 9 feet was secured; this depth was then increased to 13 feet, then to 17 feet, and finally, in 1888, Congress determined that a depth of 23 feet should be given. This method has greatly increased the ultimate cost of what has been finally accomplished.

Though the question of maintaining an open cut through Mobile Bay and the use of auxiliary works or alternative plans have been under consideration since the inauguration of the work, the matter did not assume grave importance until the extreme depths of channel were adopted. With moderate depths the amount of filling in the cut was not of such extent as to make the work of its removal a serious item, but the rate of filling has increased more rapidly in proportion than the increase of depth of channel, and it now appears desirable to give full consideration to the question of probable cost of maintenance before expending additional large sums of money for increasing the capacity of the existing channel.

Plans of improvement which will obviate the necessity for such large outlays for maintenance may be of much greater first cost, but it is to be considered whether they are not the more economical in the end.

While it is necessary in the interest of commerce and navigation that the present channel should be maintained in a state of efficiency by an annual expenditure for maintenance until such time as the construction of auxiliary works or adoption of other plans may render such large expenditure for maintenance unnecessary, it appears that before any large sum is expended for widening the existing channel by dredging

the whole subject should be referred to a Board of Engineer Officers for full consideration and report.

Very respectfully, your obedient servant,

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

Hon. DANIEL S. LAMONT,
Secretary of War.

REPORT OF CAPT. WILLIAM T. ROSSELL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., January 16, 1896.

GENERAL: In the river and harbor act of August 17, 1894, it is provided that—

Harbor at Mobile, Alabama: The Secretary of War shall cause a survey to be made to ascertain the cost of widening the channel of said harbor, now in course of improvement, to obtain a width of one hundred feet at bottom, with a proper slope therefor * * * and the expenses * * * shall be paid out of any appropriations made for the improvement of the channel of Mobile Harbor.

The duty of making the survey thus provided for was assigned to Lieut. Col. A. N. Damrell, Corps of Engineers, by Department letter of August 20, 1894.

It was thought better to wait until all other work under the last project was finished before making this report, so that all data as to slope might be available. The project has now been finished, and I have the honor to submit the following report:

The project completed in October, 1895, was that adopted in August, 1888, modified as required by the river and harbor act of September 19, 1890. The object was to afford a channel from the city of Mobile, Ala., to the Gulf of Mexico of 280 feet width on top of cut with a central depth of 23 feet at mean low water, and the channel was afterwards extended up the Mobile River to the mouth of Chickasabogue Creek.

Since the completion of this work vessels drawing more than 23 feet have come to the wharves of Mobile loaded to their full capacity and gone to sea.

The nature of the bottom encountered during dredging operations has varied greatly in different parts of the channel, being at different points sand, soft and hard clay, silt, and shell reefs. At many places has been found a soft ooze lying over the bottom of the bay in depths of from 1 to 5 feet. This material is moved about under the action of the winds and causes fills in the dredged channel. It is, however, so soft that vessels can go through considerable depths of it without difficulty. These different materials took up under the conditions of the channel different slopes, which vary, as shown by the last surveys, from 1 on 3 to 1 on 20.

Another fact that was ascertained during the work was that in order to gain a channel depth of 23 feet it was necessary to excavate about 5 feet below this point in many places. The payments made for dredging were by the yard, measured in the scows. Careful measurements of the yardage measured in situ and compared with it, scow measurement, show an increase in scow measurements over measurements in situ varying from 20 per cent in some places to 50 per cent in others.

Allowing for all the above, the following estimate in submitted:

550,000 cubic yards of material, chiefly sand, from Mobile River channel, at 17 cents	$93,500
17,250,000 cubic yards of material, chiefly soft blue mud, little sand and shell, from Mobile Bay channel, at 8 cents	1,380,000
Removal of 290 linear feet of the west upper obstructions at head of Mobile Bay, at $20	5,800
Removal of logs and other sunken obstructions from the channel of Mobile River and Bay	10,000
Engineering, superintendence, and contingencies	150,700
Total	1,640,000

The prices submitted, viz, 17 cents per yard in Mobile River and 8 cents per yard in the bay, seem to me small; but the prices paid under the last contract for this work were, river 16.5 cents and bay 7.7 cents. Whether such advantageous bids can be secured again is unknown.

In conclusion, I desire to call attention to the fact that this long dredged channel, nearly 33 miles continuous cut, must be maintained by annual work. My predecessor, Lieutenant-Colonel Damrell, estimated the cost of this at $60,000 a year. During freshets snags and logs are brought down the river, many of which find their way into the channel. There is on hand now a small steamer, the *Maggie*, which can be used for removing these, and I would recommend that authority be given by law to purchase a dredging plant to be kept for use in maintaining the channel. The cost of this plant will be $125,000.

For the employment of this plant, I would recommend that authority be given to draw the necessary money under the provisions of section 4 of the act of July 5, 1884.

I inclose herewith the report of Asst. Engineer P. C. Boudousquie.

Very respectfully, your obedient servant,

WM. T. ROSSELL,
Captain, Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

REPORT OF MR. P. C. BOUDOUSQUIE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., November 20, 1895.

SIR: The act of Congress dated August 17, 1894, made provision for ascertaining the cost of widening the channel of the harbor at Mobile, Ala., to obtain a width of 100 feet at the bottom, with a proper slope therefor.

Dredging operations at that time had not sufficiently progressed to warrant an estimate, it being deemed more reliable to depend rather on the more practical results of actual dredging, and to await the completion of the first project. Since the completion of that project of "a channel of 280 feet top width, with a central navigable depth of 23 feet at mean low water, from the mouth of Chickasabogue Creek to the Gulf of Mexico," on October 3, 1895, which has allowed more than 74 vessels of a draft of from 22 feet to 23.9 feet to proceed to sea without detention from the port of Mobile, it is believed that an enlargement of the channel as above contemplated is practicable by redredging and widening the central cuts, and also by providing a proper western slope therefor, the eastern slope having been already secured by the work of preceding years.

The pressing requirements of an increasing commerce render it imperative to widen the channel of Mobile River, thus affording greater facilities to shipping interests.

The lines defining the navigable channel of Mobile Bay, and recommended to your consideration, are so prepared as to eliminate as much as permissible short turns or angles offered by the intersection of the various courses.

The chief difficulty experienced during the prosecution of this work of improvement is to maintain, through a very soft blue clay bottom, a channel of a specified

width, and it will be therefore necessary to provide for the maintenance of said channel for a few years following its completion an annual allotment of $60,000.

The lumber and timber commerce of Mobile within recent years has assumed large proportions, necessitating the location of extensive booms on the smaller streams tributary to Mobile River, and also the towing from more distant points of rafts of hewn and rough logs. A number of these logs insufficiently secured while in transit escape and eventually lodge in the main channel, thereby rendering its navigation quite dangerous. Daily complaints are made of the presence of these sunken obstructions, alarming owners of vessels seeking this port.

From time to time the existing gaps between the obstructions erected during the civil war were widened. As it is proposed to enlarge the channel and rectify the entrance to Mobile River, 290 linear feet of the west upper obstructions, located at the head of Mobile Bay, will have to be removed.

The great length of the dredged channel (33.08 miles) necessitates the erection of aids to dredging operations, consisting of yellow-pine piles with the bark on, bolted and chained, to which tide gauges are secured. The ravages of the *Teredo navalis* are considerable, especially in lower Mobile Bay, compelling the renewal of these clusters, corresponding to fixed points, on the eastern bank of the dredged channel.

The outlet to the Gulf of Mexico through the main ship channel of Mobile Bay still deepens by natural process, as evidenced by the passage of the steamship *Mendota* across the outer bar on August 8, 1895, drawing 24.83 feet at mean low water.

Material to be excavated from the channel of Mobile River to secure a depth of 23 feet and a bottom width of 100 feet, with a proper slope therefor.

Location.	Linear feet.	East slope, cubic yards.	Re-dredging central cuts, cubic yards.	Enlarging central cuts, cubic yards.	West slope, cubic yards.	Total, cubic yards.	Character of material.
From Station O, R. A. with center of draw pier, mouth of Chickasabogue, to 2,060 feet south.	2,060	7,086	.....	39,368	10,234	56,688	Sand and silt.
From 1,960 feet south of Station 1 to 20 feet south of Station 2.	700	.....	.....	13,101	.....	13,101	Do.
From 40 feet south of Station 3 to Station A.	2,600	8,412	.....	60,088	8,412	76,912	Sand and black mud.
From Station A to 840 feet south of Station 6.	5,920	.....	.....	129,468	9,579	139,047	Compact sand, little yellowish clay.
From 840 feet south of Station 6 to Station B.	2,040	.....	.....	43,626	12,180	55,806	Sand, with yellowish clay.
From Station B to Station C..	3,610	.....	50,777	79,333	3,172	133,282	Sand, little bogue ore, "ferrous oxide."
Triangular cut, Station C.....	1,000	.....	.....	14,932	.....	14,932	Sand.
From Station C to deep-water basin, mouth of Mobile River.	2,085	.....	.....	60,232	.....	60,232	Sand, little mud.
Total.....	.....	15,498	50,777	440,148	43,577	550,000	

Material to be excavated from the channel of Mobile Bay to secure a depth of 23 feet and a bottom width of 100 feet, with a proper slope therefor.

Location.	Linear feet.	Redredging central cuts, cubic yards.	Enlarging central cuts, cubic yards.	West slope, cubic yards.	Total, cubic yards.	Character of material.
From I. P. mouth of Mobile River to 552 feet south of Station F, rectifying east and west lines of channel.	6,065	.....	342,370	.....	342,370	Sand, little clay, and blue mud.
From 552 feet south of Station F to Station G.	3,889	.....	.....	111,024	111,024	Sand, little mud.
From Station G to Station H...	8,930	238,132	.....	223,249	461,381	Stiff mud.
From Station H to Station I....	2,228	.....	184,347	.....	184,347	Soft blue clay.
From Station I to Station 21...	10,568	254,413	386,709	515,190	1,156,312	Do.
From Station 21 to Station 24 ..	7,920	137,280	259,294	429,000	825,574	Sand, little mud.
From Station 24 to Station 37 ..	34,320	889,777	1,144,000	1,430,000	3,463,777	Deadened shell reefs.
From Station 37 to Station J...	10,391	344,827	387,935	539,960	1,272,722	Soft blue mud, little shell.
From Station J to Station L....	1,758	117,199	70,320	99,033	286,552	Soft blue clay and ooze.
From Station L to Station 49...	19,531	1,302,066	781,239	1,328,107	3,411,412	Very soft blue clay and ooze.
From Station 49 to Station 51 ..	5,280	351,999	193,599	323,400	868,998	Ooze overlying stiff clay.
From Station 51 to Station M..	28,059	1,870,599	904,122	1,332,802	4,107,523	Soft and stiff clay, little ooze.
From Station M to Station 64..	6,264	324,643	146,738	91,191	562,572	Soft blue clay, little ooze.
From Station 64 to Station N..	5,739	195,436	.....	.....	195,436	Mud and sand.
Total	.....	6,026,371	4,800,673	6,422,956	17,250,000	

* * * * * *

Very respectfully, your obedient servant,

P. C. BOUDOUSQUIE,
Assistant Engineer.

Capt. WM. T. ROSSELL,
Corps of Engineers.

APPENDIX Q.

INSPECTION OF THE IMPROVEMENT OF THE SOUTH PASS OF THE MISSISSIPPI RIVER.

REPORT OF MAJ. JAMES B. QUINN, CORPS OF ENGINEERS, INSPECTING OFFICER, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., July 1, 1896.

GENERAL: I have the honor to submit my report for the fiscal year ending June 30, 1896, upon the improvement of the South Pass of the Mississippi River.

The work pertaining to the improvement is carried on under the direction of the legal representatives of James B. Eads, deceased, by authority of an act of Congress approved March 3, 1875.

The work done during the year consisted in the maintenance of structures already built, and was not of any great volume.

During the year "a channel having a navigable depth of 26 feet" was maintained through the shoal at the head of South Pass, and through the Pass itself, except during five days when the channel in Grand Bayou Reach did not contain the required depth.

The required channel "through the jetties" was maintained during the year except for eight days in May and four days in June. It is required that the channel shall be "26 feet in depth, not less than 200 feet in width at the bottom, and having through it a central depth of 30 feet without regard to width."

Beyond the sea ends of the jetties the legal channel was maintained during the year.

During the year the dredge boat worked one hundred and fifty-four days in the jetty channel, and fifteen days in South Pass.

On account of the subsidence of the Delta of the Mississippi River and a consequent settling of Port Eads tide gauge it became necessary to readjust the plane of average flood tide to which depths in the jetty channel are reduced, and in accordance with the instructions of the honorable Secretary of War the datum plane for the year 1895, and each succeeding year, will be the actual average flood tide for each preceding year.

Accordingly, the original plane of average flood tide, which was 2.76 feet on Port Eads gauge, was changed to 3.89 feet for 1895, and 3.68 feet for 1896.

The report of Mr. C. Donovan, assistant engineer, is herewith, together with charts and plates to accompany the same. As the report is complete in detail, I respectfully invite attention to it, and submit it without comment.

Estimate of funds required for examinations and surveys at South Pass, Mississippi River, during the fiscal year ending June 30, 1898.

1 assistant engineer	$2,700
1 assistant engineer	1,500
1 steam engineer	1,200
1 water-level observer	120
6 seamen	3,370
Rent of office	180
Rent of quarters for assistant engineers	240
Mileage and traveling expenses	150
Repairs to launch and boats	600
Supplies for launch and office	240
Contingencies	1,700
Total	12,000

Money statement.

July 1, 1895, balance unexpended	$2,219.64
Amount allotted for fiscal year 1895–96 under act of August 11, 1888	10,000.00
	12,219.64
Amount expended during fiscal year	11,085.08
July 1, 1896, balance unexpended	1,134.56
Amount allotted for fiscal year 1896–97 under August 11, 1888	10,000.00
Amount available for fiscal year ending June 30, 1897	11,134.56

Statement of expenditures on account of appropriation for examinations and surveys at South Pass, Mississippi River, for the fiscal year ending June 30, 1896, made in compliance with section 4 of river and harbor act of August 11, 1888.

Amount appropriated by act of August 11, 1888 ..... $10,000.00

EXPENDITURES.

1 assistant engineer four months, at $200	$800.00
1 assistant engineer nine months, at $225	2,025.00
1 assistant engineer thirteen months, at $125	1,625.00
1 engineer, launch, thirteen months, at $100	1,300.00
1 first-class seaman thirteen months, at $70	910.00
2 first-class seamen twenty-six mouths, at $65	1,690.00
1 first-class seaman thirteen months, at $60	780.00
1 water-level observer thirteen months, at $10	130.00
2 first-class seamen nine and three-fourths days, at $2	19.50
1 clerk one month, at $125	125.00
Rent of office and quarters, Port Eads, La., thirteen months, at $35	455.00
Stationery	50.37
Repairs to steam launch *General Reese*	76.85
Ship chandlery, hardware, etc	210.19
Coal	550.15
Tide gauge	136.00
Traveling expenses	24.35
Metal-work foundation of an instrumental station in the Gulf	83.10
Trap bucket	17.55
Lumber	43.32
Express charges	9.25
Repairs to t elescope of transit	13.50
Repairs to tide gauge	9.20
Telegrams	1.75
Total expenditures	11,085.08

Respectfully submitted.

JAMES B. QUINN,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

REPORT OF MR. C. DONOVAN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Port Eads, La., June 30, 1896.

SIR: I have the honor to submit my report for the year ending June 30, 1896, upon the condition of the works carried on under the direction of Messrs. James F. How and Estill McHenry, of St. Louis, Mo., for the improvement of the South Pass of the Mississippi River, by authority granted them as the legal representatives of James B. Eads, deceased, in an act of Congress approved March 3, 1875; also the amount and character of the work done during the year to maintain said works and the channel created by them.

The following charts and plates accompany this report:

No. 1. Chart of the channel from South Pass Light-House through the jetties to deeper water in the Gulf.

No. 2. Chart of a part of the Gulf of Mexico, giving depths out to that of 100 feet.

No. 3. Chart of a part of South Pass, from South Pass Light-House to Grand Bayou.

No. 4. Chart of a part of South Pass, from Grand Bayou to the Head of the Passes.

No. 5. Chart of the Head of the Passes.

Plate I. Diagrams showing changes in the Gulf for each year from 1876 to 1895.

Plate II. Diagrams giving the results of velocity and sediment observations.

Plate III. Hydrographs of Carrollton gauge.

AT THE HEAD OF THE PASSES.

Upper dam.—During the months of January and February the ends of this structure were strengthened by the addition of willows weighted with earth in sacks.

This dam is now 535 feet long, and is in good condition. The following materials were added to it during the year: Forty-eight piles, 175 linear feet of 12 by 12 inch timber, 29 screw bolts, 460 cords of willows, and 1,900 sacks of earth.

Cut-off dike.—This dike was built last year for the purpose of closing the channel way between the upper dam and the mainland below it. A small area of land immediately below the upper dam was connected with and made to serve as a portion of the barrier, but as it began to wear away it was decided to continue the dike to a juncture with the upper dam, a distance of 307 feet.

This work consists of two rows of piles 10 feet apart, the piles in each row being 9 feet apart, and between them willows weighted with earth in sacks are placed.

This dike is in good condition. The following materials were used in its construction during the year: Seventy-one piles, 383 cords of willows, and 1,973 sacks of earth.

West T-head.—Some of the piling in the river side of this work, which is the west jetty, was renewed, the piles connected by 12 by 12 inch timbers, and willows weighted with earth in sacks were added.

The structure is in fair condition, and the following materials were added to it during the year: Forty piles, 256 linear feet of 12 by 12 inch timber, 65 screw bolts, 281 cords of willows, and 1,682 sacks of earth.

East T-head.—One hundred and eighty-three cords of willows, and 1,157 sacks of earth were placed at the upper end of this work to arrest the flow of water between it and the land adjacent to it, which was being cut away by the current.

Mattress sill across Southwest Pass.—This submerged dam remained unchanged during the year. Since it was completed in December, 1878, 400 feet of it, commencing at a point 100 feet from the east end, has washed away. For the next 500 feet it has settled an amount varying from 2 to 22 feet, and throughout the greater portion of the remaining distance it has settled quite uniformly from 2 to 4 feet.

Mattress sill across Pass a Loutre.—The original length of this sill was 3,000 feet, and with the exception of probably 500 feet of the west end it is still in place. It is covered by a heavy deposit of sand, so that the depth of water over it is less than when it was placed, in 1877.

The locations of all works at the Head of the Passes are given on Chart No. 5.

IN SOUTH PASS.

Willows, weighted with earth in sacks, were placed at the junction of the shore with each of the four sheet-piling dams which project from the west shore of the pass below the Head of the Passes Light-House. This was done to prevent the swash from cutting away the shore at its junction with the dams.

Sixty-five cords of willows and 600 sacks of earth were used in this work.

These dams are in good condition and their location is given on Chart No. 5.

In Goat Island Reach.—The wing dams in this reach are in good condition, and, with the exception of adding 16 cords of willows to one of them, no work was done on them during the year.

In Grand Island Bayou Reach.—Wing Dams Nos. 3, 4, 6, 8, 9, 10, 15, and 16 had 2 piles, 314 cords of willows, 20 linear feet of 12 by 12 inch timber, 7 screw bolts, and 617 sacks of earth added to them. These and such others as it is deemed necessary to maintain are in good condition.

AT THE MOUTH OF SOUTH PASS.

All the works at this locality are represented on Chart No. 1.

East Jetty.—No work has been done on this jetty since 1893. Its condition is as follows: For 3,400 feet from East Point, where it begins, it is buried by the land formation which has taken place since its construction. For the next 2,800 feet it is as originally built of mattresses of willows weighted with rock; the riprap covering the top mattress is about 3 feet below the surface of the water at the present average flood tide.

The remainder of this jetty is capped by a concrete wall built upon the original foundation mattress, except for a distance of 625 feet where the original line was deviated from in order to avoid the débris of the previous wall.

With the exception of 304 feet, in two sections of older construction, and another of the newer, where the foundation was undermined, causing the wall to settle, although it was not otherwise displaced, the work is in fair condition.

The average height of this wall above the present plane of average flood tide (3.68 feet on Port Eads gauge) is 0.95 of a foot. The average subsidence during the year was 0.14 of a foot, and since its completion in September, 1889, the average subsidence has been 1.1 feet.

The profiles on Chart No. 1 explain the settlement of this wall at every point.

The shore line of the reef to the eastward of this jetty receded 150 feet during the year.

West Jetty.—Three hundred and sixty feet of the outer end of this jetty is from 3 to 5 feet below the surface of the water and there is a depth of 2 feet of sand over the concrete work. The remainder of this work, as is represented on Chart No. 1, is buried by the land formation which it has caused.

Inner East Jetty.—Two cribs were placed on this jetty near its sea end, being built upon older ones which had settled to the water. They are 59 and 287 feet long, respectively, 8 feet wide and 3 feet high, and are built in the usual manner of 12 by 12 inch timbers, and are filled with stone.

The upper section of the work, 1,900 feet in length, is not considered of further importance, since the land which has formed inside it has consolidated to such an extent that it is not anticipated that this portion will require further attention. The channel row of piles in about two-fifths of the remaining portion have been renewed, cypress piles being used, and this row will be entirely renewed in due time.

Willows and stone have been added wherever the condition of the work most demanded. The work on the whole is in fair condition, and at present is well above the highest tide.

The materials used in this jetty during the year are as follows: Eight thousand and seventy-one cords of willows, 1,399 cubic yards of stone, 451 piles, 4,273 linear feet of 12 by 12 inch timber, 148 screw bolts, and 539 driftbolts.

Inner West Jetty.—As previously reported, 100 feet of the sea end of the work is destroyed, 4,800 feet in length remaining in place. The channel row of piles was renewed in three sections, aggregating 1,650 feet in length, and willows and stone were added to these sections which are in good condition. The remaining 3,150 feet of the jetty is in very indifferent condition.

The following materials were used in its maintenance during the year: One hundred and eighty-five piles, 1,249 cords of willows, and 215 cubic yards of stone.

WING DAM.

Of the 33 wing dams now maintained for the improvement of the jetty channel, 24 of them were repaired during the year by the addition of the following materials: Seven hundred and twenty-seven cords of willows, 37 cubic yards of stone, 123 piles, 1,038 linear feet of 12 by 12 inch timber, 168 screw bolts, 36 driftbolts, and 255 sacks of earth.

With the exception of four of them these structures are in good condition.

DREDGING.

From June 22, 1895, to June 21, 1896, both inclusive, the dredge boat worked one hundred and sixty-nine days of ten hours each, as follows: Fifteen days in Grand Bayou Reach and one hundred and fifty-four days in the jetty channel.

THE PLANT.

A floating pile driver was built, including the barge, 55 feet long, 24 feet wide, and 3½ feet depth of hold; three barges and two wharves were rebuilt, and a set of ways built for hauling out barges and smaller craft.

THE FORCE EMPLOYED.

The averages force employed during the year, including officers, mechanics, and laborers was 50 in number.

EXAMINATIONS AND SURVEYS.

The results of examinations and surveys made during the year are added to and compared with those deduced in former years, and are so tabulated or represented graphically as to be readily understood.

AT THE HEAD OF THE PASSES.

The chart of this survey is No. 5. In comparison with a similar survey made one year previous the section on line G. H. shoaled throughout. The shoaling is quite uniform, and averages about 2½ feet; the greatest shoaling varies from 2 to 6 feet at a locality from 1,800 to 2,600 feet from the east shore.

This section is now less in area than it was in 1875. The section on line I J is, as a general thing, shoaler than it was one year ago, although the change is slight. The area of this section is greater than in 1875, because of the deep portions leading into South Pass and Pass a Loutre, at either end of upper dam. The greater portion of it, however, in Southwest Pass and Pass a Loutre has shoaled.

On line A B a general shoaling averaging about 2 feet resulted.

As a general result the area at the Head of the Passes shoaled during the year, but has deepened since 1875.

The present channel at the Head of the Passes is practically as shown on Chart No. 5, the required "navigable depth of 26 feet" having been maintained during the year.

SURVEY OF SOUTH PASS FROM ITS HEAD TO SOUTH PASS LIGHT-HOUSE.

During the month of September, 1895, while the river was low, a complete survey of South Pass was made, the charts of which are Nos. 3 and 4, and the following table compiled from them gives the depth and width of channel in the different reaches:

Tabulated statement of the depth and width of channel through South Pass of the Mississippi River, from East Point to 30-foot depth in the main river, given in separate reaches one-fourth of a mile in length, from a survey made in September, 1895.

Locality.		Available depth.	Available width of—	
From—	To above East Point.		26-foot channel.	30-foot channel.
East Point	¼ mile	27	140	(1)
Above East Point:				
¼ mile	½ mile	27	145	(2)
½ mile	¾ mile	29	230	(3)
¾ mile	1 mile	32	220	110
First mile				
1 mile	1¼ miles	30	230	10
1¼ miles	1½ miles	29	235	(4)
1½ miles	1¾ miles	27	250	(5)
1¾ miles	2 miles	27	200	(6)
Second mile		27	200	(*)
2 miles	2¼ miles	29	325	(7)
2¼ miles	2½ miles	30	380	120
2½ miles	2¾ miles	31	390	240
2¾ miles	3 miles	31	390	250
Third mile		29	325	(*)
3 miles	3¼ miles	31	340	190
3¼ miles	3½ miles	30	320	90
3½ miles	3¾ miles	29	310	(8)
3¾ miles	4 miles	31	300	100
Fourth mile		29	300	(*)
Above East Point:				
4 miles	4¼ miles	31	310	70
4¼ miles	4½ miles	29	360	(9)
4½ miles	4¾ miles	30	300	80
4¾ miles	5 miles	33	220	140
Fifth mile		29	220	(*)
5 miles	5¼ miles	28	180	(*a*)
5¼ miles	5½ miles	27	150	(*b*)
5½ miles	5¾ miles	27	150	(*c*)
5¾ miles	6 miles	27	150	(*d*)
Sixth mile		27	150	(*)
6 miles	6¼ miles	26	90	(*e*)
6¼ miles	6½ miles	27	180	(*f*)
6½ miles	6¾ miles	29	310	(*g*)
6¾ miles	7 miles	30	370	10
Seventh mile		26	90	(*)
7 miles	7¼ miles	29	330	(*h*)
7¼ miles	7½ miles	30	360	60
7½ miles	7¾ miles	35	320	250
7¾ miles	8 miles	36	310	240
Eighth mile		29	310	(*)

* Very wide.

Tabulated statement of the depth and width of channel through South Pass of the Mississippi River, etc.—Continued.

Locality.		Available depth.	Available width of—		Locality.		Available depth.	Available width of—	
From—	To above East Point.		26-foot channel.	30-foot channel.	From—	To above East Point.		26-foot channel.	30-foot channel.
Above East Point:					Above East Point:				
8 miles	8¼ miles	32	280	190	10 miles	10¼ miles	34	310	**250**
8¼ miles	8½ miles	31	270	180	10¼ miles	10½ miles	39	300	**210**
8½ miles	8¾ miles	32	230	180	10½ miles	10¾ miles	33	290	**210**
8¾ miles	9 miles	34	210	140	10¾ miles	11 miles	31	280	**110**
Ninth mile		31	210	140	Eleventh mile		31	280	**110**
9 miles	9¼ miles	32	230	90	11 miles	11¼ miles	41	(*)	**310**
9¼ miles	9½ miles	27	250	(*m*)	11¼ miles	11½ miles	28	(*)	(*o*)
9½ miles	9¾ miles	29	350	(*n*)	11½ miles	11¾ miles	28	(*)	(*s*)
9¾ miles	10 miles	47	310	250	11¾ miles	12 miles	†31	(†)	(†)
Tenth mile		27	230	(*)	Twelfth mile		28	(*)	(*)

* Very wide.

† In Mississippi River, above Head of Passes.

Length of the portion of this reach not having a central depth of 30 feet.

	Feet.		Feet.
(1)	1,320	(*d*)	1,320
(2)	1,320	(*e*)	1,320
(3)	450	(*f*)	1,320
(4)	770	(*g*)	580
(5)	1,320	(*h*)	350
(6)	510	(*m*)	1,180
(7)	380	(*n*)	70
(8)	1,020	(*o*)	750
(9)	750	(*s*)	950
(*a*)	610		
(*b*)	1,320	Total	18,930
(*c*)	1,320		

The change in depth throughout the pass during the year is in favor of shoaling. Some sections deepened while others shoaled, but on the whole the change was unimportant.

Since 1875 the pass has shoaled decidedly, the greatest shoaling having taken place in the deepest places, while the shoaler ones have changed the least.

The required "navigable depth of 26 feet" was maintained during the year, except for five days from May 1 to 5, both inclusive, when such depth did not obtain in Grand Bayou Reach. This temporary shoaling was caused by large volumes of sand which were moving through this reach.

THE CHANNEL THROUGH THE JETTIES.

The channel through the jetties and beyond them to deeper water in the Gulf is given on chart No. 3.

It shoaled during the year an amount averaging about 1½ feet, except in a reach 1,500 feet in length from the sea end of the jetties. In this reach the channel is deeper than it was one year ago.

On April 26 the river began to fall rapidly after attaining a stage of 13.6 feet on Carrollton gauge, and a consequent shoaling of the channel resulted. From May 20 to 27, both days inclusive, being eight days, the 26-foot channel was not 200 feet wide within a reach from 9,000 to 10,600 feet below East Point.

On May 27 the river began to rise again, and much sand was brought down. The channel shoaled so that from June 15 to 18, both inclusive, being four days, the 26-foot channel was less than 200 feet wide within a reach from 842 to 8,875 feet below East Point, and during the same period there was not "a contral depth of 30 feet" at ten

localities, aggregating 1,500 feet in length, within a reach from 5,000 to 8,680 feet below East Point.

With these exceptions the required channel "26 feet in depth, not less than 200 feet in width at the bottom, and having through it a central depth of 30 feet without regard to width," was maintained during the year.

Tabulated statements relative to the available depths and widths of channel through the jetties, in separate reaches of 2,000 feet each, according to surveys made during the fiscal year ending June 30, 1896.

Date.	Distances from East Point, in feet.								
	0 to 2,000.			2,000 to 4,000.			4,000 to 6,000.		
	Available depth.	Available width of—		Available depth.	Available width of—		Available depth.	Available width of—	
		26-foot channel.	30-foot channel.		26-foot channel.	30-foot channel.		26-foot channel.	30-foot channel.
1895.									
July	31.7	300	50	31.7	305	85	32.0	250	50
August	32.2	270	75	31.8	310	65	31.8	240	50
September	31.8	240	35	31.7	265	50	31.8	225	50
October	30.9	260	20	30.9	245	30	31.8	230	35
November	31.7	250	50	31.5	270	35	31.8	205	20
December	31.3	235	40	31.4	265	40	31.1	240	35
1896.									
January	31.3	275	45	30.9	290	60	32.1	275	60
February	31.3	290	40	31.1	255	45	31.3	240	40
March	30.6	260	20	30.3	280	30	30.5	250	20
April	30.5	255	35	30.0	290	35	30.3	265	35
May	30.3	210	35	30.0	250	5	30.2	240	20
June	30.2	240	10	30.2	260	15	30.2	230	25

Date.	Distances from East Point, in feet.								
	6,000 to 8,000.			8,000 to 10,000.			10,000, to 12,000.		
	Available depth.	Available width of—		Available depth.	Available width of—		Available depth.	Available width of—	
		26-foot channel.	30-foot channel.		26-foot channel.	30-foot channel.		26-foot channel.	30-foot channel.
1895.									
July	31.5	230	40	31.8	240	20	32.1	240	30
August	31.3	220	55	31.1	225	45	31.4	240	40
September	31.4	230	25	31.4	235	30	31.4	220	30
October	31.3	220	35	31.5	220	20	31.2	210	15
November	31.3	200	35	32.1	210	25	32.1	225	30
December	31.4	240	40	31.8	210	35	31.2	220	20
1896.									
January	31.9	265	45	31.3	250	45	32.4	255	60
February	31.3	235	30	31.5	225	35	31.5	230	25
March	31.1	230	40	32.0	225	35	32.0	230	40
April	30.4	240	40	31.0	230	35	31.9	230	45
May	30.0	230	10	31.0	*210	25	32.4	210	30
June	†30.2	230	10	†30.2	‡220	10	32.2	200	25

*Less than 200 feet in width for eight days, from May 20 to 27, both inclusive.
†Less than 30 feet from June 15 to 18, both inclusive.
‡Less than 200 feet in width for four days, from June 15 to 18, both inclusive.

Beyond the ends of the jetties, and on a direct course from there to sea, the required channel was maintained during the year.

The following table gives the available depths through the jetties at various dates since 1875, and explains the changes in the depth of that channel from that time to the present:

Table giving the depths of water through the jetties at various dates.

Date.	Distances from East Point, in feet.					
	0 to 2,000.	2,000 to 4,000.	4,000 to 6,000.	6,000 to 8,000.	8,000 to 10,000.	10,000 to 12,000.
1875—June	22.5	18.7	16.7	10.2	9.7	9.2
1876—May	23.3	20.3	22	21	17.1	15
August	23.5	19.6	21	23.5	23	19.8
November	22	20.3	21.1	21.2	21.1	20.3
1877—March	24.1	21.1	23.2	22	21.2	20.5
July	24.9	24	26	23.8	23.5	20.3
October 25 to December 14	26.3	24.4	28.5	24.2	23	23.7
1878—March	26	25.9	35.5	25.4	24.3	23
December	28.4	26.4	35.7	27.1	25.3	23
1879—March	28.6	27.5	43.4	27	27	27
June	27.5	28.4	47.7	29.2	29.2	28
July 8	30.5	30.7	.....	31	30.7	30.5
December	31	31	48.3	31.7	31.8	30.8
1880—June	31	32.5	47.8	31.4	35.1	32
July	30.5	31	44	30.8	31.5	30.5
August	30.5	30.4	46	32	32	30.5
September	30.7	31	44.4	30.6	32	31
October	31	31.5	41	30.3	31	30.5
November	30.6	31	40.3	30.8	30.9	30.5
December	30.9	30.6	43	30.8	31	30.3
1881—January	30.5	30.4	41.9	33.8	30.7	30.3
February	30.4	30.2	41.6	32	31	30
March	31.5	31.2	41.3	32	22	30.5
April	30.4	30	43	33	33	30.5
May	30.2	30.5	42.7	32.6	30.5	31.2
June	30	30.5	43.8	32	31.7	31.7
July	31	32	42.5	33.5	33	32
August	30.1	32	37.6	32	31	30.2
October	30.2	30.3	38.3	31.4	31.2	30.3
1882—January	30.5	30.4	41.3	31.1	30.2	30.7
February	31.8	36	39.7	30.5	30.8	30.2
March	31.2	30.6	39.2	30.8	31.6	32.5
April	31.7	32.6	39.6	30.5	30.3	33
May	30.5	32.5	39.4	31	31.3	31
June	30.8	35.5	39	31.3	31.3	31
July	30	32.7	38.7	30.6	31.3	31.5
August	30.3	32.2	38.1	31.8	31.8	30.5
September	30.1	31.5	38.3	31.9	30.8	30 5
October	30	31	37.1	31	31.4	31.2
November	30	32	38.1	21.5	31.2	31.2
December	31	31	37	31.2	31	30.4
1883—January	31	31	35.2	30.2	30.1	30.1
February	31.2	31.2	36	30.5	30	30.1
March	32.3	32.6	45.7	31.5	30.3	30.3
April	33.7	35	44	32.2	30	39
May	33.2	36.3	46	32.3	30.3	32.4
June	32.5	34.2	45	33.4	31	33
July	33.8	34.9	44	32	31.5	31.8
August	32.1	38.2	48	33.4	33.4	32.2
September	33.4	34.3	46	32.3	32.3	30.6
October	32.7	34.1	41.5	32	32	30.5
November	31	33.8	43.8	34.5	31.5	31
December	30.5	32.6	43	31.6	31.6	30.2
1884—January	31.2	32.2	39.2	32.7	31.8	30.3
February	32	31.5	41.3	31.6	31	30.7
March	35.7	39.5	41.6	34	33.8	38.7
April	35.3	37.3	41.5	31.7	32.7	35.4
May	34.9	35.8	42.3	34.3	35.1	33
June	35	35.8	41.1	34	35	35
August	31.9	35.8	41.9	33.9	35	32
September	32	34	39	33.1	33.7	33.5
October	31.1	33.4	38.6	32.6	32.6	32.5
November	32.8	32.8	37.2	32.2	32.4	30.8
December	31.6	32.6	37.1	31.1	31.5	31.4
1885—January	36.7	36.4	36.9	33.1	34.6	32.8
February	41.7	36.3	35.7	30.5	34.1	36.2
March	35.5	36	36.1	31	31.7	35.7
April	36	35.5	37	32	32.6	32
May	36.7	35	35.6	31.5	33.5	31.5
June	34.7	33.7	35.7	32.8	32.8	31.3
July	36.3	33.1	36.5	33.7	33.6	31
August	36.5	35.6	37.6	33	32	31
September	35.3	33,3	35,2	32,2	30,7	31,7

Table giving the depths of water through the jetties at various dates—Continued.

Date.	Distances from East Point, in feet.					
	0 to 2,000.	2,000 to 4,000.	4,000 to 6,000.	6,000 to 8,000.	8,000 to 10,000.	10,000 to 12,000.
1885—October	33.8	33.7	35.8	31.3	30.4	30.4
November	32.7	32.8	35.1	30.8	30.6	30.1
December	33	32.2	34.2	30.9	30.5	30.6
1886—January	33.6	32.5	33	30.2	30.2	28.5
February	32.8	32.8	34.1	31.3	30.9	30
March	32.8	35.8	34	35	33.1	32
April	35.4	34.5	34.5	33.7	33.7	31
May	35.9	35.6	34.2	31	36	34.4
June	38.2	35.2	33.4	33.2	34.5	36.5
July	36.7	36.7	36.2	32.8	32.7	37
August	35	36	35.7	34.8	33.8	34.7
September	34.5	35.6	34.6	33.7	33.6	33
October	35	36.2	34.4	33	34.1	33
November	34.5	35.6	34.8	32.9	33	33.5
December	34	35	35.3	33.6	32.6	33
1887—January	33.6	34	33.3	32.3	32.7	33.4
February	36.4	34.4	35.4	31.3	34.1	32.4
March	35.5	35.5	32.6	35.5	35.5	33.8
April	38.8	37	33.7	31	34.8	35.5
May	39.4	35.3	37.1	31.2	34.2	38.1
June	39	35.4	37.5	32.3	34.1	35.2
July	39	36.4	35.8	34	32	34
August	35.7	34.6	34.7	33.6	31.6	32.7
September	36	34	35	35	32.7	32.2
October	36.2	34.2	34.3	32.1	32.2	31.8
November	35.9	32.9	33.8	30.7	31.8	31.2
December	34.7	32.7	33.9	30.9	31.7	31.8
1888—January	35.6	32.5	33.7	30.5	31.5	32.2
February	34.3	32.4	32.5	31	31	32
March	34	33	32.6	30.5	31.3	30.9
April	36.3	34.8	33.8	31	35	31.4
May	35.2	35.2	34.3	31.6	33.6	33
June	32	33	33	31.4	35.5	33.2
July	34.2	34	33.8	31	31.9	33.6
August	33.7	33.7	33.7	31.2	31.2	33.2
September	32.7	32.7	32.8	30.8	31	32
October	33.3	33.3	32.3	30.6	30.4	30.4
November	31.8	32.8	31.7	30.6	30.6	30.8
December	31.4	32.4	31.6	30.3	*29.2	30.7
1889—January	31	31.3	30.6	30.3	31	30.9
February	32.4	32.5	31.8	32.8	31	32.5
March	30.2	32.2	30.4	32.3	31.8	31.6
April	30.8	32.1	31.2	32.8	32.8	30.6
May	30.8	32	30.7	32.6	31.2	30.8
June	30.4	32.2	31.3	31.5	31	30.8
July	30.3	31	31	32.4	31.3	31
August	31.7	31.4	31.5	31.6	31.4	31
September	30.9	31.3	31.2	31	31.1	.....
October	31.6	31	31.2	31	31.7	†29.6
November	31	31.2	31.2	31	31.3	31.4
December	30.8	31	31.2	31	31.7	31.2
1890—January	30.8	30.8	31.2	30.6	31	31
February	31.7	30.7	31.5	32.6	34.4	33
March	36.4	33.2	34	34	34	33.6
April	33.4	36	35	35	38.7	34.5
May	32	34	34	36	39	34
June	32	33.5	33	34	39.8	35
July	32.4	33.4	34	34	39	37
August	32	33	33	32.7	35	34
September	30.5	31.4	33	33	35	33
October	32	31	31	30.5	34	32.8
November	30.6	31.2	30.6	30.6	34	33
December	31.5	31.2	30.7	30.7	32.3	33.5
1891—January	31	31	31.2	32.2	32.3	32.5
February	31.7	31	31.4	32.5	35.2	32.7
March	32	34.3	36.4	37.5	36	34.6
April	30.5	32	36.5	39	36.4	34.2
May	30.3	32	32	35	36	34
June	33	31.1	32	34.7	37	35
July	31.4	30.4	30.4	33.3	35.8	34.8
August	31	31	31	32.3	32.9	31.4
September	30.6	30.6	30.7	31	31.5	.....
October	31	30.8	30.8	31.2	31.2	30.7
November	31.2	31	31.3	31.2	31.1	30.6
December	30.1	30.3	30.6	31.4	31.3	32
1892—January	31.3	31.6	31.3	31.3	31.8	32.2

* From December 28, 1888, to January 4, 1889, inclusive.
† From October 1 to October 5, inclusive.

Table giving the depths of water through the jetties at various dates—Continued.

Date.	Distances from East Point, in feet.					
	0 to 2,000.	2,000 to 4,000.	4,000 to 6,000.	6,000 to 8,000.	8,000 to 10,000.	10,000 to 12,000.
1892—February	30.5	30.8	30.8	31	31.1	31.7
March	30.8	30.7	31.4	31.7	31.2	31
April	32	32	33.7	32	30.5	30.6
May	*28.1	†29.6	38	35	33	32
June	‡30.4	32.3	36	37	36.6	33.2
July	31.5	33	32	35.6	38	34.2
August	31.5	33.5	33.8	34.6	34.8	35
September	31.2	32.7	31.2	33.6	33.7	33.5
October	31.8	32.5	31.8	31.5	32.7	32.3
November	31.5	32.1	31.5	32	33	32.6
December	31	31.5	31.6	32.1	33.5	33.1
1893—January	31.6	32.2	31.3	32.1	32.2	34.1
February	31.6	31.6	31	31.6	32.7	34
March	33.6	34.6	33.1	30.8	31.2	32.4
April	33.6	35	33.6	31.6	32.3	32.6
May	32	34	33	33	32.5	32
June	32.7	33	33.8	36	31.7	30.5
July	32	33.3	34	35	36.7	35
August	32	32	34	34.5	35.3	34.2
September	31.5	31.5	32.4	33.5	35.3	31.8
October	31.5	32.2	32.7	33.2	34.2	33.2
November	31.4	32.7	33.3	32.8	34.3	33
December	31	32	33	33	34.8	33.5
1894—January	32.1	32.1	33.5	33.2	36.8	34.5
February	30.6	32.2	32.6	32.6	34.5	33
March	32.8	31.8	31.7	32	34.2	34
April	34.3	31.4	32.7	33	32.3	34
May	32	32	34	34	34	33
June	32.2	31.2	32.9	33	32.7	33.6
July	32.1	31.6	31.7	31.5	31.8	32.6
August	31.2	30.5	31.2	30.2	§28.9	30.3
September	31.3	30.6	30.6	30.5	30.3	30.5
October	30.4	30.4	30.1	30.8	30.6	30.4
November	30.3	30.3	30.6	30.3	30.3	30.8
December	30.8	30.6	31.3	30.7	30.7	30.7
1895—January	31.7	32.1	32.1	31.6	31.5	31.9
February	31.9	32.4	31.7	31.8	31.8	31.8
March	32.8	32.1	31.6	31.6	31.7	32.2
April	32	31.9	31.5	31.6	31.8	32.2
May	31.4	31.5	31.4	31.4	31.9	31.6
June	31.4	31.7	31.6	31.3	31.3	31.5
July	31.7	31.7	32	31.5	31.8	32.1
August	32.2	31.8	31.8	31.3	31.1	31.4
September	31.8	31.7	31.8	31.4	31.4	31.4
October	30.9	30.9	31.8	31.3	31.5	31.2
November	31.7	31.5	31.8	31.3	32.1	32.1
December	31.3	31.4	31.1	31.4	31.9	31.2
1896—January	31.3	30.9	32.1	31.9	31.3	32.4
February	31.3	31.1	31.3	31.3	31.5	31.5
March	30.6	30.3	30.5	31.1	32	32
April	30.5	30	30.3	30.4	31	31.9
May	30.3	30	30.2	30	31	32.4
June	30.2	30.2	‖30.2	‖30.2	‖30.2	32.2

* Depth less than 30 feet from April 25 to May 6, both dates inclusive, and varied from 27.5 to 29.4 feet.

† From December 28, 1888, to January 4, 1889, inclusive.

‡ Depth less than 30 feet from May 20 to June 20, both dates inclusive, and varied from 28.1 to 29.6 feet.

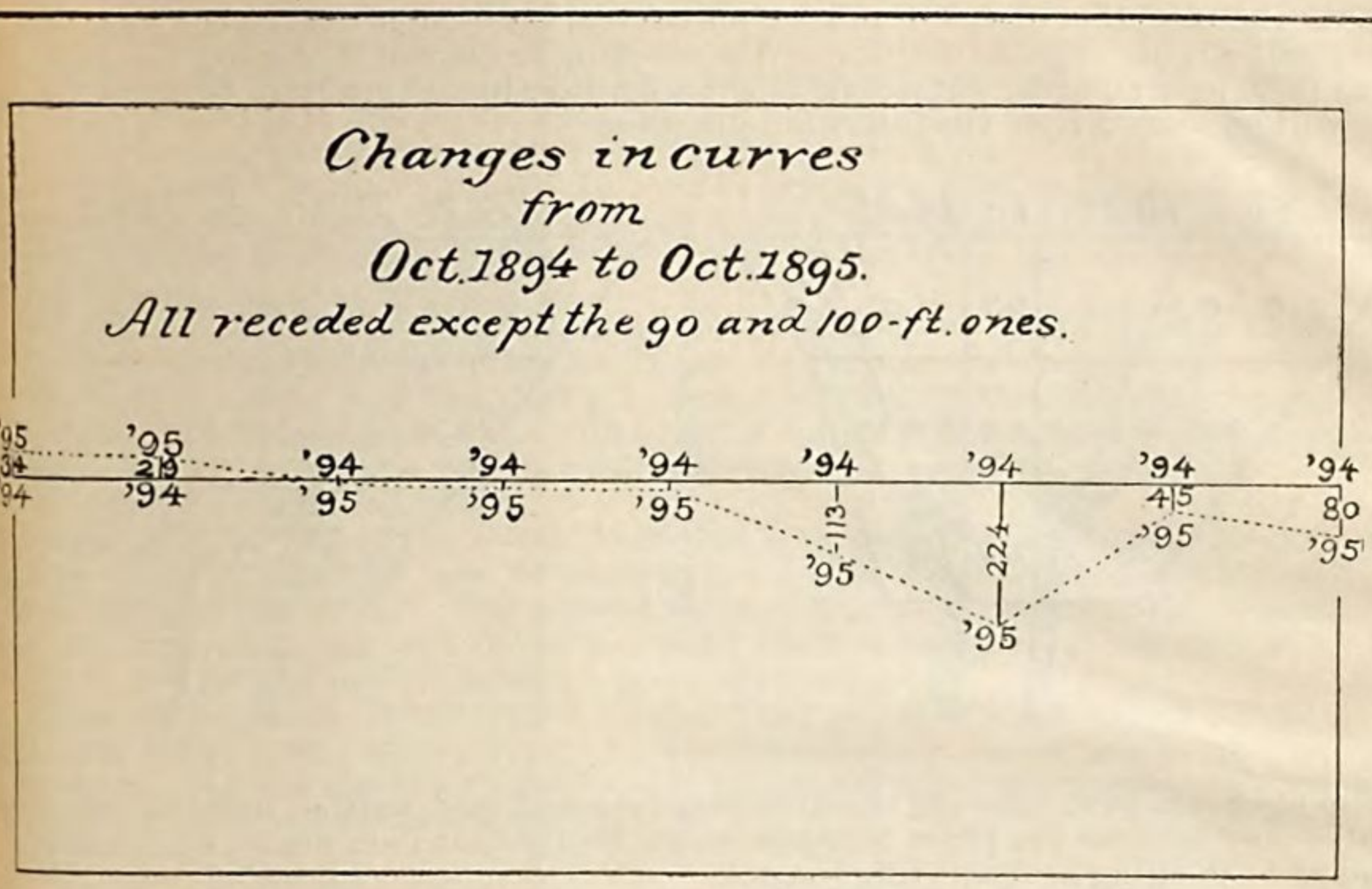
§ August 20 to 31, both dates inclusive.

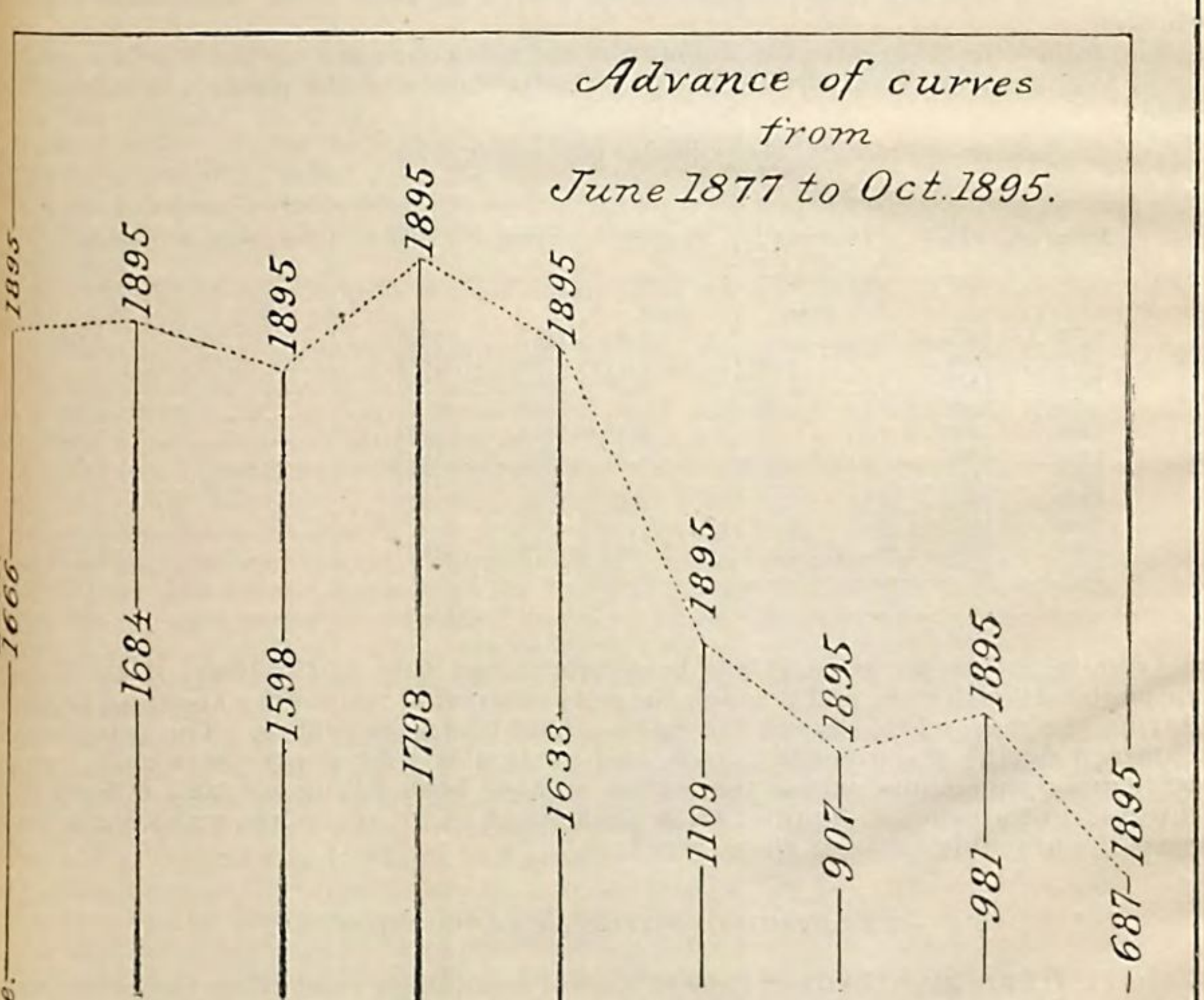
‖ Less than 30 feet from June 15 to 18, both inclusive.

SURVEY BEYOND THE ENDS OF THE JETTIES.

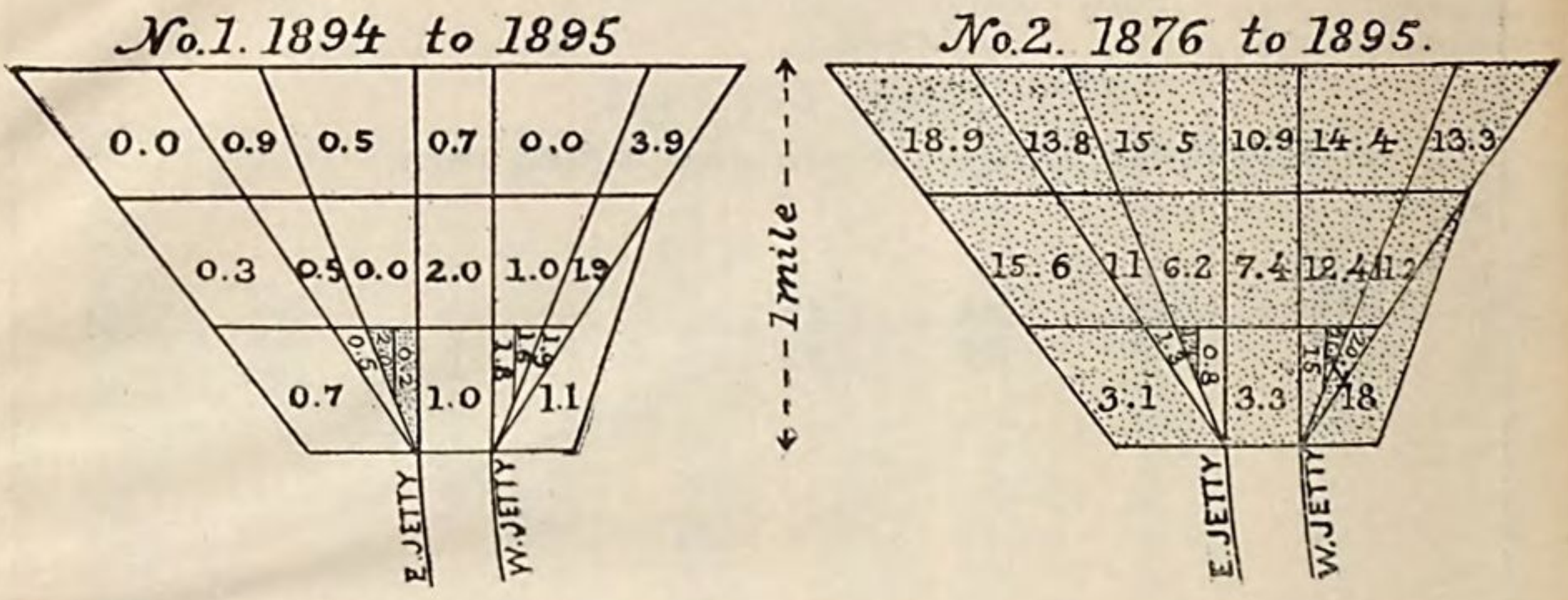
The chart of the survey is No. 2. The results deduced from the surveys from year to year and the comparisons which are made one with another give most interesting and important information.

Referring to the following diagram and those on Pl. I, it will be seen that the area under consideration deepened during the year, and in consequence, all the curves considered—that is, from 20 to 100 feet, inclusive—with the exception of the 90 and 100 foot ones, receded. The 40-foot curve shows the greatest recession of 224 feet, and the 80-foot curve the least, being 8 feet. The 90-foot curve advanced 29 feet, and the 100-foot curve 34 feet.


Changes in curves
from
Oct. 1894 to Oct. 1895.
All receded except the 90 and 100-ft. ones.
'95
'95
'94
'94
'94
'94
'94
'94
'94
'94
'94
'95
'95
'95
'95
'95
113
224
'95
'95
'95


Advance of curves
from
June 1877 to Oct. 1895.
Feet.
1666
1684
1598
1793
1633
1109
907
981
687
1895
100-ft. curve.
90 "
80 "
70 "
60 "
50 "
40 "
30 "
20 "
1877

With the exception of the 40 and 50 foot curves, the change during the year is comparatively slight. The disposition of the shoaling or deepening during the year, and since 1876, over an area containing $1\frac{1}{4}$ square miles, immediately in front of the jetties will be known from the following diagrams:



The figures in each area are the differences, in feet and tenths, between the mean depths obtained for the years between which comparisons are made, and denote the amount of shoaling or deepening in each.

No. 1 compares the mean depths in 1894 with those in 1895. Shaded areas have shoaled.

The following table gives the amount of the mean change over the whole area since 1876, and is revised in accordance with a readjustment of the plane of average flood tide:

Mean change over whole area.

From—	To—	Deepened.	Shoaled.	From—	To—	Deepened.	Shoaled.
		Feet.	*Feet.*			*Feet.*	*Feet.*
1876....	1877.....	.....	0.40	1887.....	1888.....	1.52	0.36
1877....	1878.....	1.80	.....	1888.....	1889.....	1.52	.....
1878....	1879.....	.....	2.26	1889.....	1890.....	.....	1.08
1879....	1880.....	.02	.....	1890.....	1891.....	.....	2.25
1880....	1881.....	.....	2.18	1891.....	1892.....	.....	1.64
1881....	1882.....	.....	1.31	1892.....	1893.....	.....	2.05
1882....	1883.....	.25	.....	1893.....	1894.....	1.05	.....
1883....	1884.....	.....	3.62	1894.....	1895.....	.81	.....
1884....	1885.....	1.17	.....				
1885....	1886.....	.....	.14	1876.....	1895.....	.....	12.11
1886....	1887.....	.....	1.44				

From what has preceded it has been determined that at the Head of the Passes, throughout South Pass, and through the jetty channel at its mouth a shoaling occurred during the year, while beyond the jetties there was a deepening. The same results obtained during the preceding year, and particularly for many years past, has the wide and deep channel which the jetties created been filling up, and it may be of interest to those not so familiar with the subject as we are to know the cause, or at least the probable cause of these results.

THE STAGE OF RIVER AT CARROLLTON, LA.

On Pl. III are given hydrographs of Carrollton gauge, comparing the record from July 1, 1882, to July 1, 1884, with that from July 1, 1894, to July 1, 1896.

During the first period there were twelve months of high river, six months of low river, and six months during which the river was rising or falling, while during the latter period there was no rise of sufficient extent or duration to be characterized a high-river period; there were fifteen months during which the river was low, and during the other nine months there were six rises, neither of which was of sufficient height or duration to impart to the current sufficient power to maintain in suspension the sediment brought down by it.

By reference to earlier reports it will be learned that an excellent channel was obtained through the jetties, and that from February, 1883, to August, 1888, the dredge boat was not in commission.

Since 1883 the high-river periods have been of shorter duration, and in consequence of this decrease in volume there has been a corresponding decrease in the slope which gives to the current the necessary power to transport its burden of sediment, and the result is that it is left in the channel.

Each little rise that has occurred during the past two years has brought its increment of sediment to the channel. It can not reach the Gulf, as there is no power to transport it. Meanwhile the Gulf is deepening by the action of its currents, and thus it is that during such exceptionally low stages of the river the channel shoals and the Gulf deepens.

To other causes may be attributed the decadence of South Pass. The works which were built at the Head of the Passes to increase the volume of water have greatly deteriorated, and the Pass a Loutre crevasse, which discharges a portion of the river water into the Gulf at a point but 2 miles distant from where the river divides into three passes, would seem a destructive agent not only to South Pass but to Southwest Pass as well.

At one time the flow into South Pass was so great that Mr. Eads contemplated placing a sill across the pass to decrease it. This was obviated, however, by the deterioration of the works. The cause was removed, and if other conditions remained the same it would seem that the earlier high rivers would give to South Pass a sufficient volume for the maintenance of an excellent channel.

On the other hand, if the works at the Head of the Passes were still intact as originally built, and Pass a Loutre crevasse closed, then the volume of water which obtained during the past two years would not be sufficient to maintain the required channel by the force of the current alone.

VELOCITY, SEDIMENT, AND DISCHARGE OBSERVATIONS.

In the reports of the Chief of Engineers for 1886, 1889, and 1890 will be found the results of sediment and velocity observations from 1877 to 1890, and on Pl. II, herewith, the record is continued up to the present time.

On two days during each week samples of water, 1 quart each, were taken from a section near Port Eads. Five are taken from the center of the pass, at the surface, at 8, 10, 24 feet below the surface, and near the bottom, and three are taken at each of two stations about 150 feet from either shore, at the surface, mid-depth, and near the bottom.

The velocity of the current is then determined by five floats, at half mean depth, passing over a base of 200 feet.

In due time these samples of water are filtered, and the ratio of sediment to water by weight in each is determined, and the mean result for each day is an ordinate for the sediment curve; the proportion of sand contained in the sediment is estimated on examination of the latter under a microscope.

The volume of discharge of the three passes was ascertained when the stage of the river and other conditions were such as to insure reliable data. Two sets of observations were made in March and April; the results agree closely with those published on page 1347 of the Report of the Chief of Engineers for 1894. Those obtained April 10 are the most satisfactory on account of the conditions having been more favorable; they give to South Pass 7 per cent, to Southwest Pass 45 per cent, and to Pass a Loutre 48 per cent of the volume of the river. On that day Carrollton gauge read 11 feet, and on April 24 it recorded 13.6 feet, which was the highest reading during the year.

On February 15 I made simultaneous determinations of the volume of discharge near the head of South Pass and near Port Eads, and the results were almost identical. I repeated these determinations April 11, and found that the lower section discharged 1,514 cubic feet per second less than the upper. On this day there was a stormy southeast wind, which had greater effect at the lower section than at the upper, and under the circumstances, also in view of the previous results, and that the water of the pass was confined between its banks in both cases, we may conclude that the discharge at the upper and lower section is practically the same.

The average slope of South Pass from year to year is given further on in this report.

In compliance with your request, I made determinations of the slope from South Pass Light-House to the ends of the jetties; but as there are comparatively few days during the year when a staff gauge can be read with accuracy at the latter place, the results which are equitably comparable with those from Port Eads gauge are correspondingly few.

For four days, from April 24 to 27, inclusive, the conditions were favorable for accurate determinations, and on the 25 Carrollton gauge registered 13.6 feet, which was the highest record during the year.

The average result for these four days gives the slope to the ends of the jetties at high tide 0.39 of a foot, and at low tide 0.40 of a foot; the slope to Gulf level was

0.59 of a foot at high tide, and 0.69 of a foot at low tide. From these results it follows that the slopes from the end of the jetties to Gulf level at high tide is 0.2 of a foot, and at low tide 0.3 of a foot.

THE CHANGES IN THE PLANE OF AVERAGE FLOOD TIDE, AND WHAT CAUSES THEM.

The plane of average flood tide, to which soundings were reduced from 1875 to 1895, was indicated by a reading of 2.76 feet on Port Eads gauge, and was determined from readings of that gauge from August 20 to November 9, 1895.

This gauge was established one-half mile above the mouth of South Pass, and would therefore practically give Gulf-level readings. The result of these determinations, though for a brief period, were verified by one year's observations in 1877. From year to year, with occasional exceptions, the determination of average flood tide on Port Eads gauge have resulted in a greater reading on that gauge. In the meantime the jetties were being built, were finally completed, and the gauge was then 2½ miles from the mouth of the pass—that is, from the ends of the jetties.

The difference between the earlier and later records was too great to be attributed to the effect of the jetties, and it became of interest to know the cause of the change.

The Port Eads gauge was tested from time to time by reference to bench marks considered permanent, and was always maintained at the same height with reference to them, so that the gauge was considered permanent, and if this proved to be the case, then the change in the plane of average flood tide must be due to an elevation of the Gulf level.

In order to obtain data relating to the subject, a self-registering tidal apparatus was, on March 2, 1894, put in operation in Garden Island Bay, which is an arm of the Gulf to the eastward of South Pass, and on July 23, 1895, another gauge was established in East Bay, to the westward of South Pass, and the records of each were referred to Port Eads gauge.

The following table contains these records for a period of time during which the three gauges were in operation.

Table giving the tidal readings on gauges Port Eads, Garden Island Bay, and East Bay, the first being in South Pass and the other two in bays to the eastward and westward, respectively, of South Pass, and so situated as to give Gulf-level readings.

Lunation.		High tide on gauges.			Low tide on gauges.		
From—	To—	Port Eads.	Garden Island Bay.	East Bay.	Port Eads.	Garden Island Bay.	East Bay.
1895.	1895.						
July 27	August 22	3.858	3.576	3.592	2.544	2.159	2.172
August 23	September 18	3.994	3.898	3.810	2.776	2.601	2.430
September 19	October 16	4.378	4.314	4.128	3.210	3.093	2.812
October 7	November 12	3.922	3.931	3.806	2.662	2.589	2.352
November 13	December 9	3.634	3.580	3.530	2.189	2.063	1.884
1896.	1896.						
December 10	January 6	3.567	3.422	3.323	2.166	1.904	1.760
January 7	February 2	3.841	3.506	3.453	2.421	2.049	1.839
February 3	February 29	3.618	3.264	3.158	2.394	1.954	1.758
March 1	March 28	3.518	3.181	3.059	3.436	2.032	1.753
Mean readings		3.814	3.630	3.539	2.533	2.271	2.084
Mean tide		3.174	2.951	2.812			

	Garden Island Bay gauge.	East Bay gauge.
Slope from Port Eads gauge to Gulf level at high tide	0.184	0.275
Slope from Port Eads gauge to Gulf level at low tide	0.262	0.449
Slope from Port Eads gauge to Gulf level at mean tide	0.223	0.362

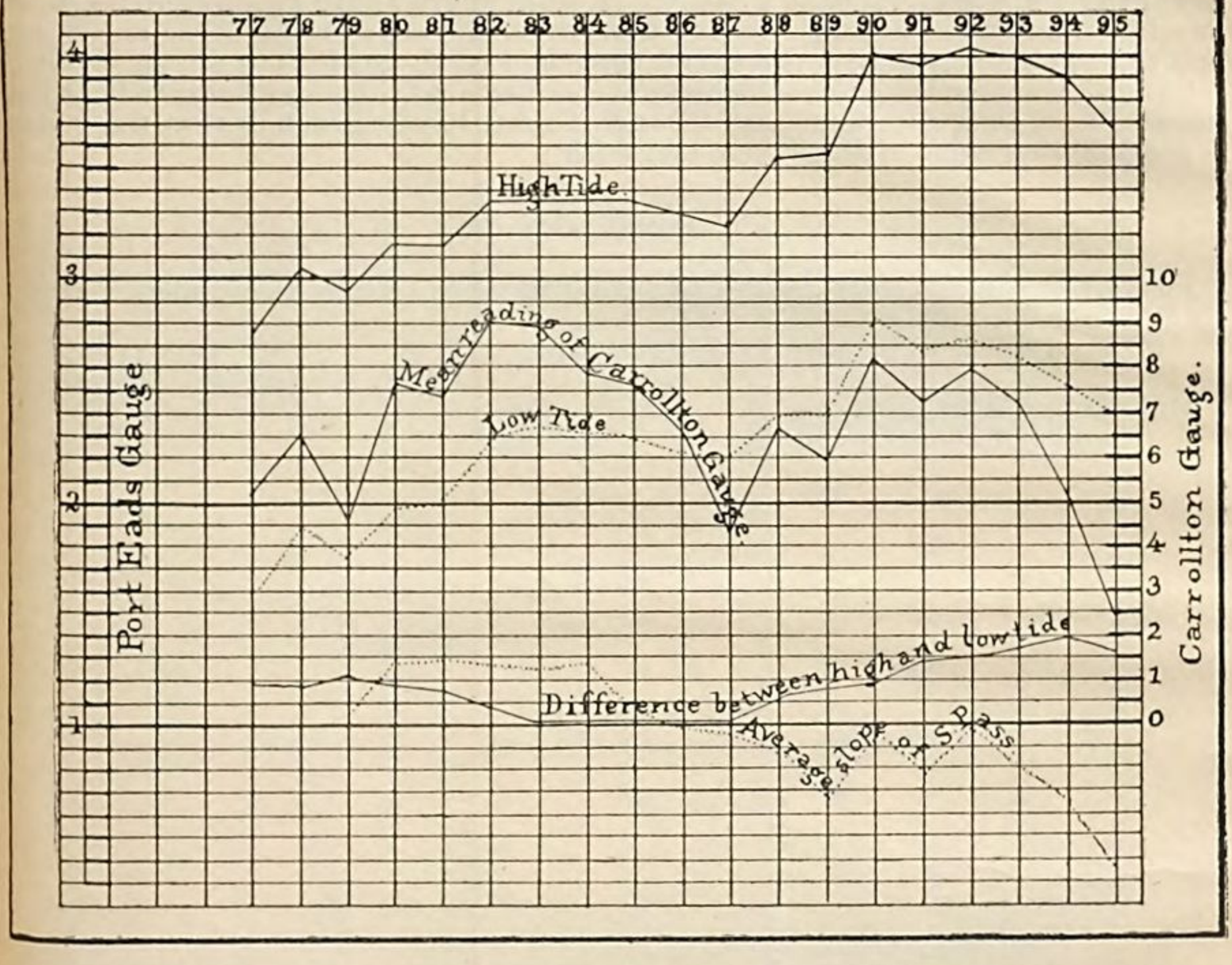
From the preceding it will be seen that the average flood tide on Port Eads gauge is about two-tenths of a foot higher than on that in Garden Island Bay, and three-tenths of a foot higher than East Bay, and that each is respectively 1.05, 0.87 and 0.77 feet higher than the plane as originally established.

As Garden Island Bay receives the water coming through Pass a Loutre crevasse, the surface of the bay would be slightly higher than that of East Bay, although if

the crevasse did not exist the records of the bay gauges would not be identical for short periods of time, because the effect of the wind is not usually the same in either bay, but for a long period this effect would be compensating.

We find, then, that the average flood tide of the Gulf reads 1 foot more on Port Eads gauge than it did in 1875, and that the change is not due to any effect caused by the jetties, and must, therefore, be due either to the settlement of the Port Eads gauge or to an elevation of the level of the Gulf.

The following plate contains a very interesting record from 1877 to 1895, inclusive:



The average high and low tide on Port Eads gauge, the difference between them, the average reading of Carrollton gauge, and the average slope of South Pass are the ordinates for each year.

I need not enter into details relative to these results, but would again refer to the decrease in the river's volume, as indicated by the Carrollton gauge record, since 1883, and particularly since 1893, and invite attention to the variation in the difference between high and low tide at Port Eads and to the decrease in the slope of South Pass.

Confining our investigations to this particular locality, and basing conclusions upon evidence here obtained, we could not decide positively whether the change which is taking place is due to the subsidence of the delta or to an elevation of the surface of the Gulf, but it would seem more logical to assume the former than that a variation in the level of the Gulf would be so irregular as the data on the preceding plate would indicate.

This subject has been investigated by the Mississippi River Commission in connection with a redetermination of Gulf level, and it has been ascertained that "the Port Eads hydrograph shows a very decided and gradual change in the relations between the Gulf level and the gauge zero with the bench marks to which it is referred," and it was concluded that "the most plausible explanation of this seems to be a gradual subsidence of the whole delta."

At the same stage of the river the banks of the passes bear about the same relation to the surface of the water as they did many years ago. When they are overflowed a deposit of sediment is left upon them, and if the delta did not settle it would seem that in time the water would be confined within its banks, but as it is not we may conclude that the subsidence of the delta from time to time is about equal in vertical height to the deposit of sediment during each overflow.

The change in the elevation of the piling in the jetties and of the foundations of buildings with reference to Gulf level give evidence of delta subsidence, and similar evidence obtains throughout the whole delta.

From time to time during the past seventeen years 175,000 tons of ballast material taken from vessels has been distributed in this vicinity, besides the many thousand tons of different materials used in the construction of the jetties, and this would seem a potent factor in augmenting the subsidence, particularly at this locality, where the delta is of the most recent formation.

THE NAVIGATION OF THE CHANNEL.

During the months of March and April I reported the grounding of three steamers in South Pass, one of them at a locality 1½ miles above South Pass Light-House and two in Grand Bayou Reach. Two of them drew 25 feet and the other one 23 feet, and they were delayed five, three, and three and three-fourths days, respectively.

Careful examination of the channel gave evidence of sufficient water to float these vessels; sand lumps were moving through Grand Bayou Reach at that time, and it is possible that some of them were met with.

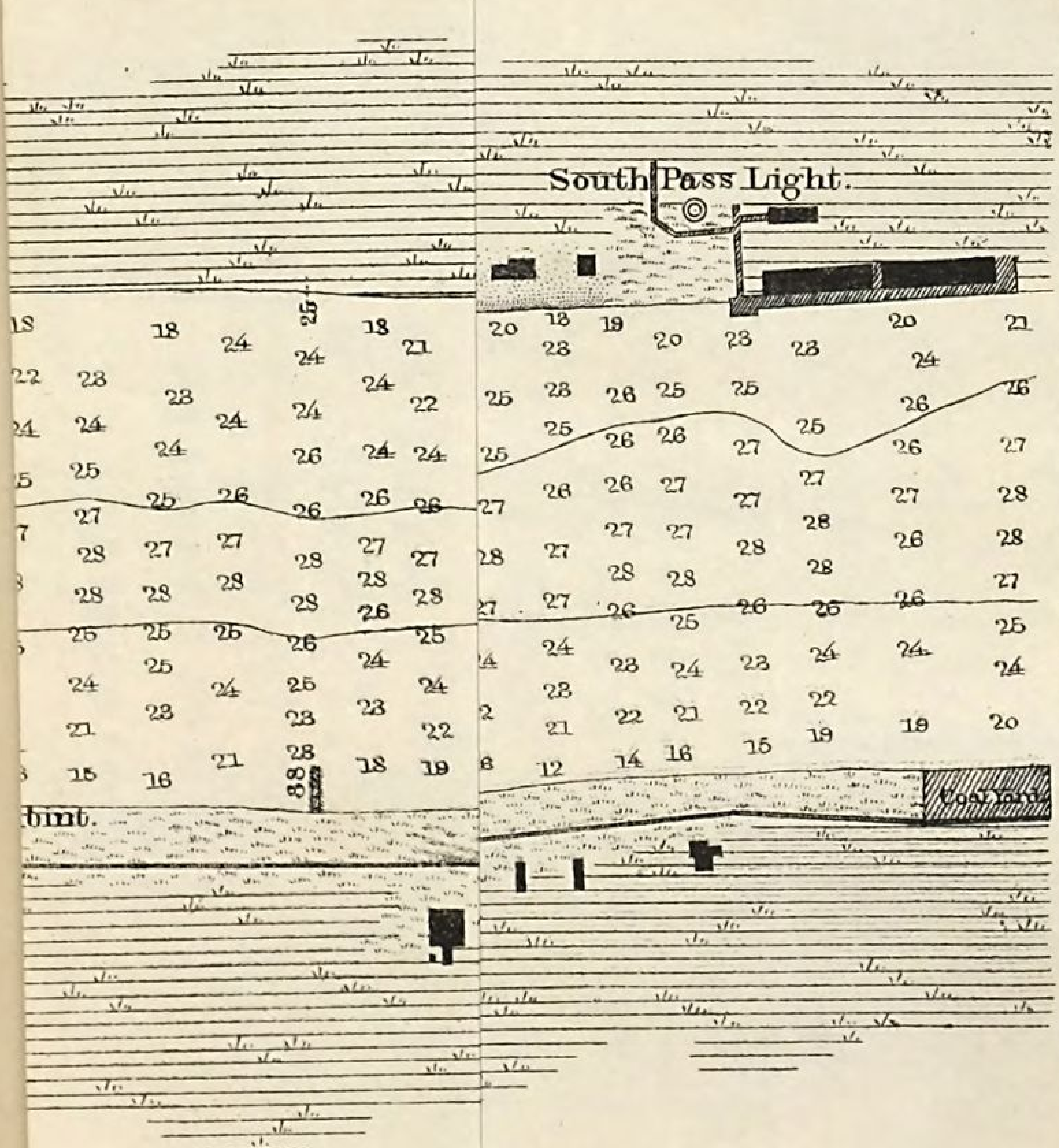
CONCLUSION.

For faithful and efficient assistance during the year I desire to commend Assistant Engineer G. W. Lawes.

Very respectfully, your obedient servant,

C. DONOVAN,
Assistant Engineer.

Maj. JAMES B. QUINN,
Corps of Engineers, U. S. A.



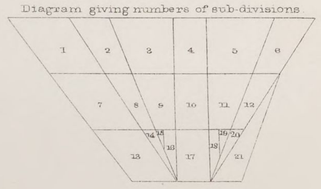
the year ending June 30,1896.

James B. Quinn

Major, Corps of Eng'rs. U. S. A.

Eng 54 2

Diagram giving numbers of sub-divisions



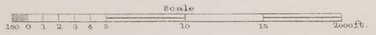
Note.

Depths are expressed in feet and refer to the plane of average flood tide indicated by a reading of 2.76 feet on U.S. Engineer's gauge near South Pass light-house.

Soundings October 17, 18, 19, 23, 24, 1895.

Carrollton gauge reading 0.6 to 1.0 foot.

Scale



Add 1.1 feet to depths on this chart to reduce to readjusted plane of average flood tide for 1895.

East Jetty

Light

West Jetty

Wreck

True Meridian.

No. 2
CHART
OF A PART OF
GULF OF MEXICO
seaward from the ends of
South Pass Jetties.

SURVEYED & PLOTTED

UNDER THE DIRECTION OF

Major J. B. Quinn, Corps of Eng'rs, U.S.A.

BY

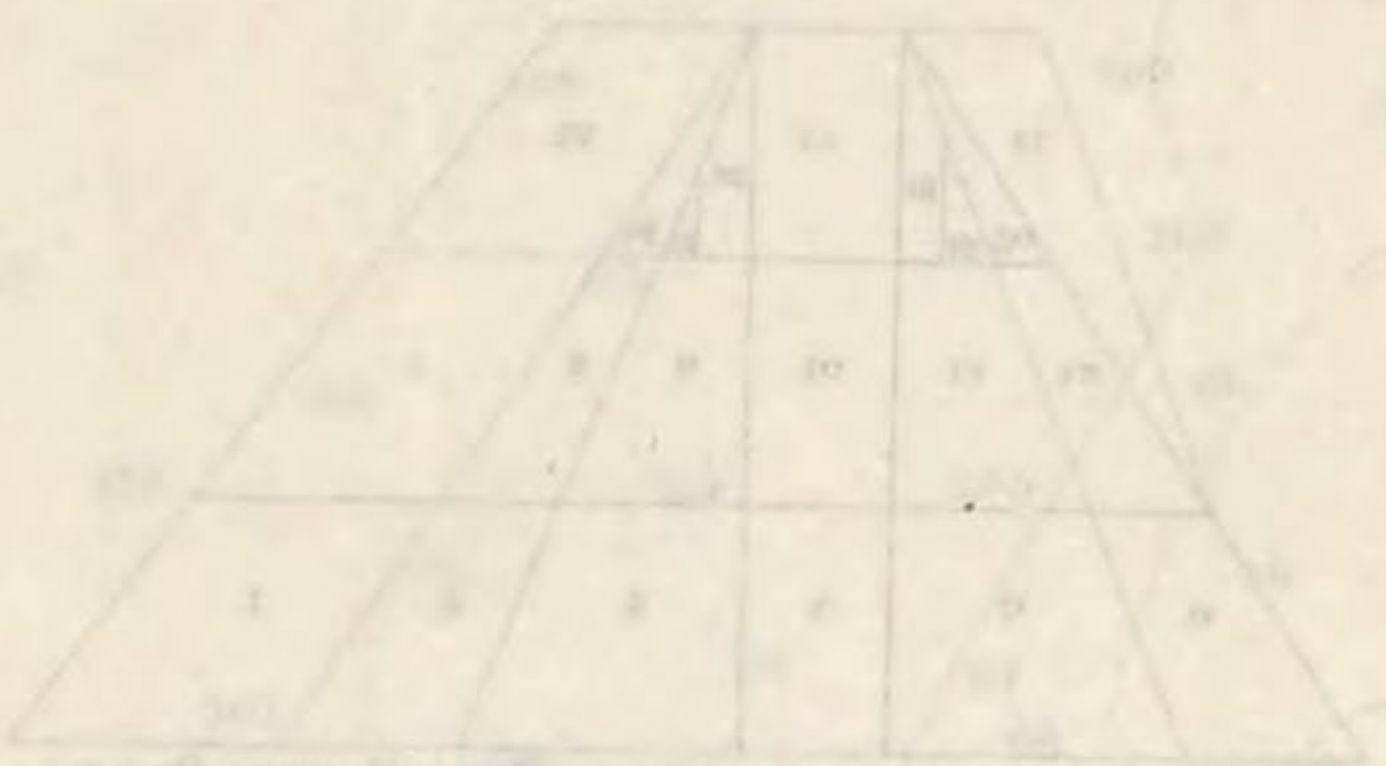
C. Donovan, Assist. Eng'r.

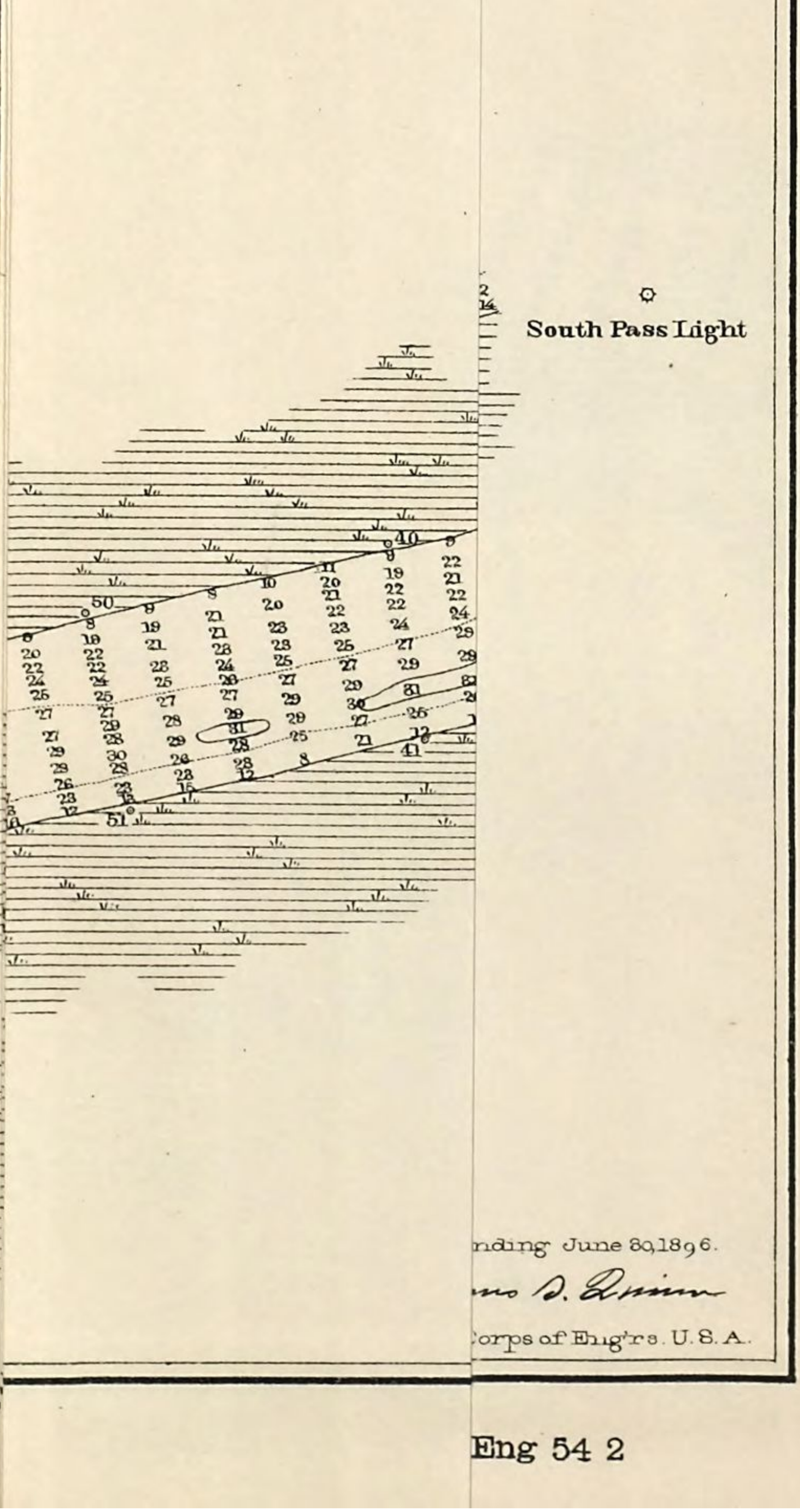
To accompany annual report for the year ending June 30, 1896.

James B. Quinn

Major, Corps of Eng'rs, U.S.A.

ANDREW B. GRAHAM, PHOTO-LITHO, WASHINGTON, D.C.

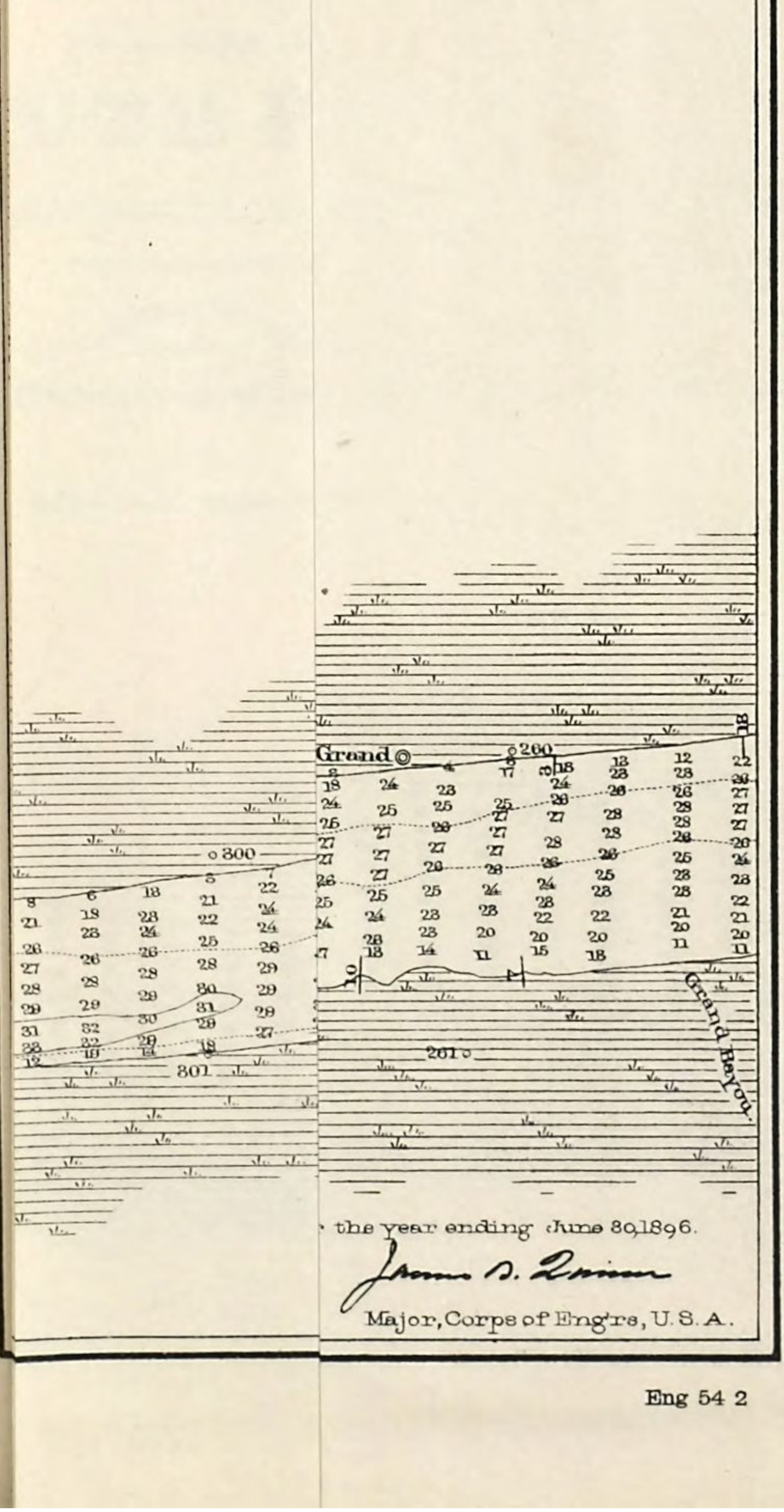




nding June 30,1896.

Corps of Eng'rs. U.S.A.

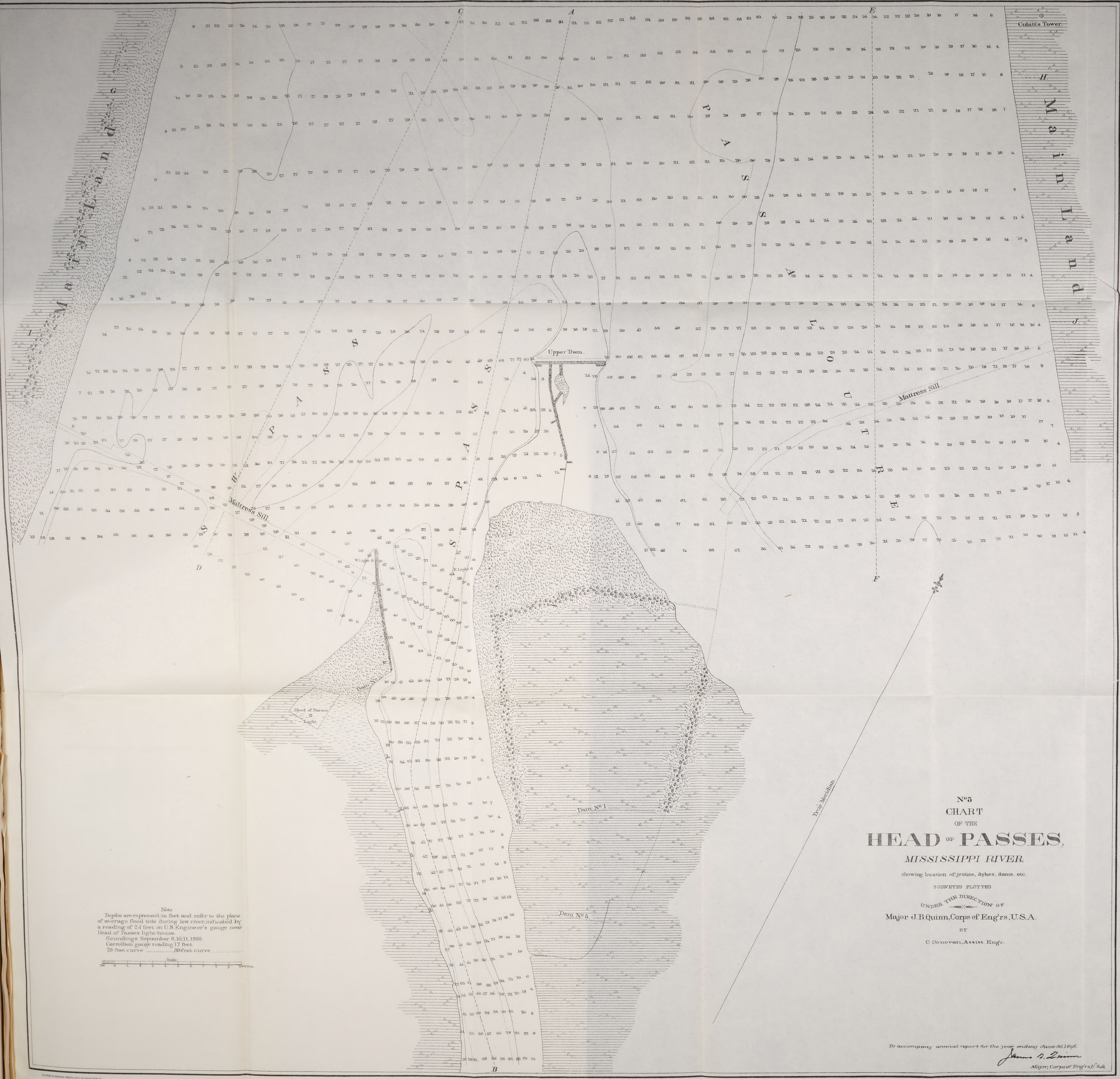
Eng 54 2



the year ending June 30, 1896.

James B. Quinn

Major, Corps of Eng'rs, U. S. A.



Note

Depths are expressed in feet and refer to the plane of average flood tide during low river, indicated by a reading of 2.4 feet on U.S. Engineer's gauge near Head of Passes light-house.

Soundings September 9, 10, 11, 1895.

Carrollton gauge reading 1.7 feet.

26-foot curve _____ 30-foot curve

Scale.

100 0 1 2 3 4 5 6 7 8 9 1000 feet.

No 5

CHART

OF THE

HEAD OF PASSES,

MISSISSIPPI RIVER.

showing location of jetties, dykes, dams, etc.

SURVEYED PLOTTED

UNDER THE DIRECTION OF

Major J.B. Quinn, Corps of Eng'rs, U.S.A.

BY

C Donovan, Assist. Eng'r.

To accompany annual report for the year ending June 30 1896.

James B. Quinn

Major, Corps of Eng'rs, U.S.A.

ANDREW B. GRAHAM PHOTO-LITHO. WASHINGTON, D.C.

PLATE I.

Comparative Diagrams

showing by mean ordinates the distances of the

Curves of various Depths

seaward from the ends of

South Pass Jetties,

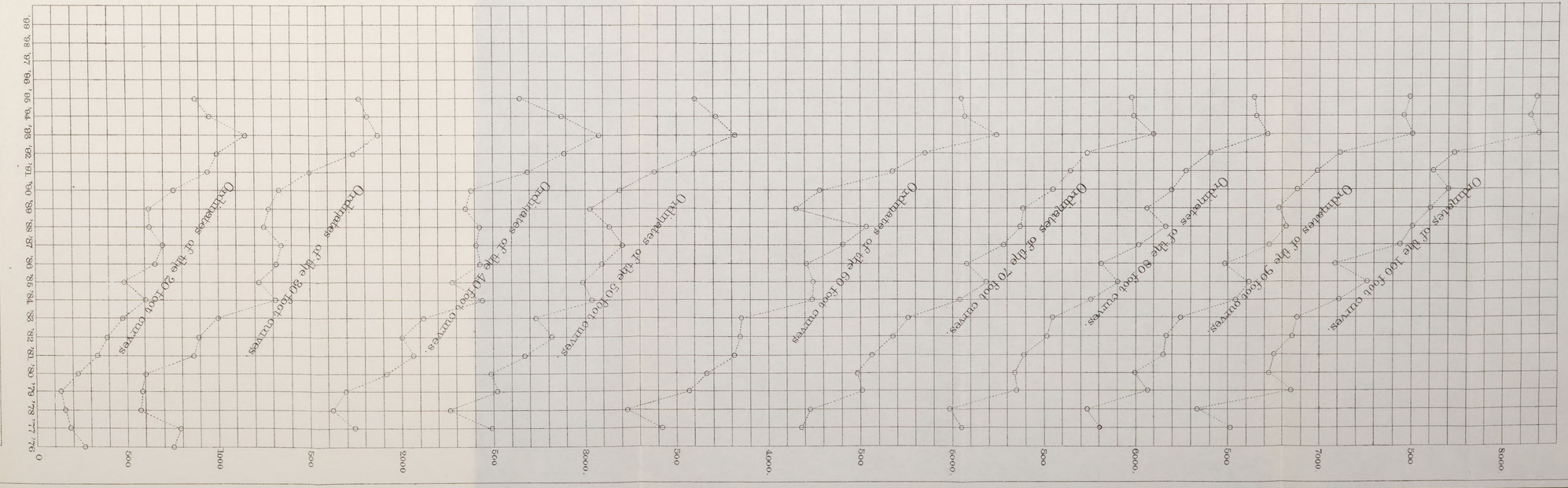
for each year from 1876 to 1895.

COMPILED BY

C. Donovan, Assist. Engr.

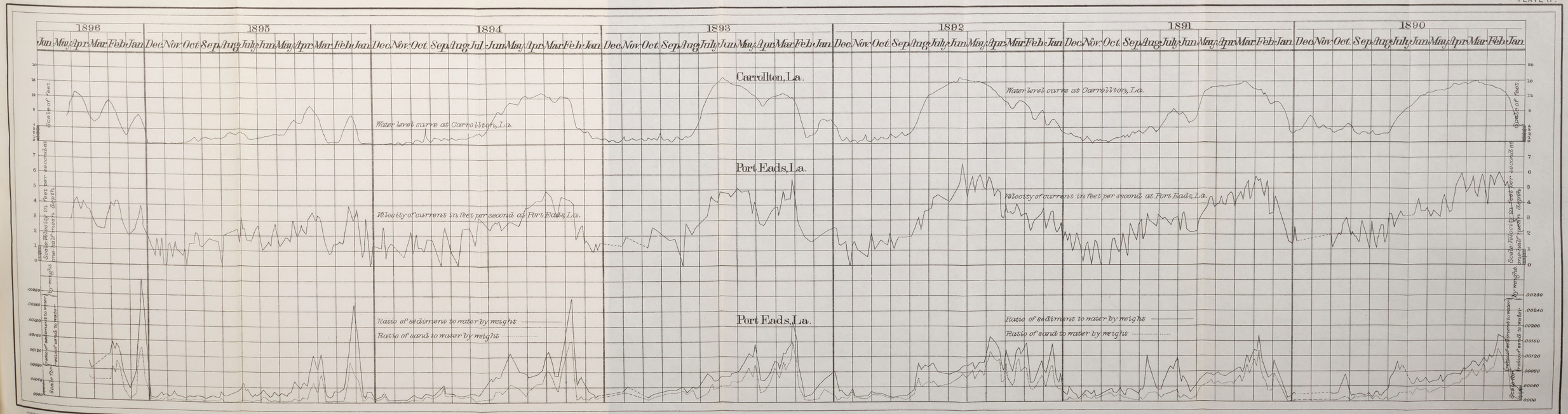
Rectangular ordinates 100 feet apart were measured from a base passing through the present ends of the jetties.

The mean of all the ordinates for each curve gives the distance of the same from the ends of the jetties.

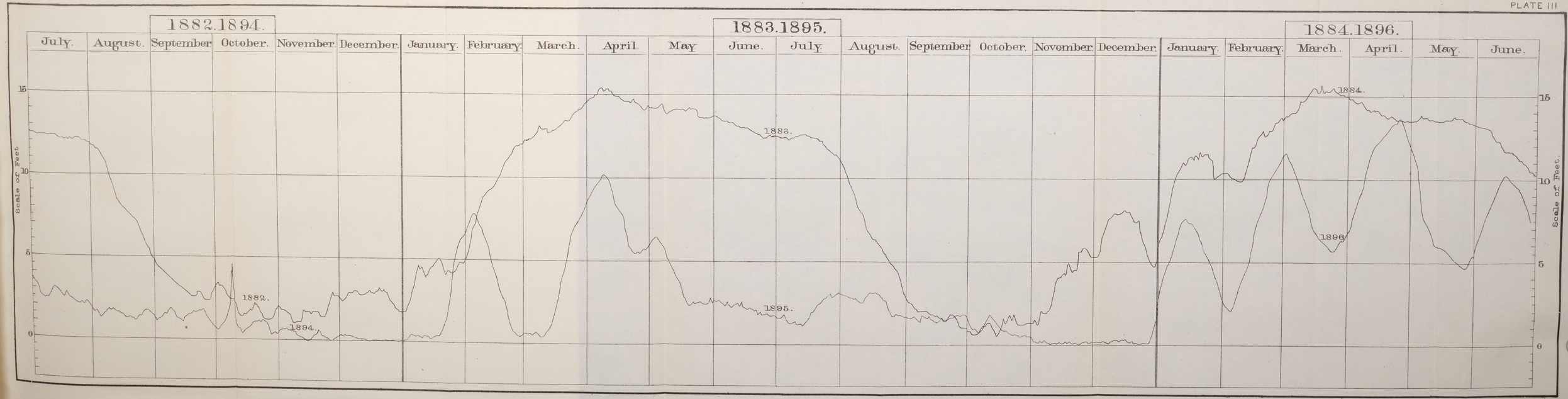


JACKSON & SHARPE PHOTO LITHO WASHINGTON D.C.

Eng 54 2


1896
1895
1894
1893
1892
1891
1890
Jan. Feb. Mar. Apr. May. Jun. July. Aug. Sep. Oct. Nov. Dec.
Carrollton, La.
Water level curve at Carrollton, La.
Port Eads, La.
Velocity of current in feet per second at Port Eads, La.
Ratio of sediment to water by weight
Ratio of sand to water by weight
Port Eads, La.
Ratio of sediment to water by weight
Ratio of sand to water by weight
Scale of feet
Scale Velocity in feet per second and Scale Ratio by weight of sediment to water and of sand to water

Eng 54 2


1882.1894.
1883.1895.
1884.1896.
July.
August.
September
October.
November
December.
January.
February.
March.
April.
May
June.
July.
August.
September
October.
November.
December.
January.
February.
March.
April.
May.
June.
15
10
5
0
Scale of Feet.
1882.
1894.
1883.
1895.
1884.
1896.

Eng 54 2

APPENDIX R.

IMPROVEMENT OF RIVERS AND HARBORS IN SOUTHERN LOUISIANA AND EASTERN TEXAS.

REPORT OF MAJ. JAMES B. QUINN, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Chefuncte River and Bogue Falia, Louisiana.
2. Tickfaw River and its tributaries, Louisiana.
3. Amite River and Bayou Manchac, Louisiana.
4. Bayou La Fourche, Louisiana.
5. Bayou Plaquemine, Grand River, and Pigeon bayous, Louisiana.
6. Bayou Courtableau, Louisiana.
7. Bayou Teche, Louisiana.
8. Channel, bay, and passes of Bayou Vermilion, Louisiana.
9. Mermentau River and tributaries, Louisiana.
10. Mouth and passes of Calcasieu River, Louisiana.
11. Harbor at Sabine Pass, Texas.
12. Sabine River, Texas.
13. Neches River, Texas.
14. Removing sunken vessels or craft obstructing or endangering navigation.

HARBOR LINES.

15. Sabine Pass, Texas.

OFFICE UNITED STATES ENGINEER,
New Orleans, La., July 16, 1896.

GENERAL: I have the honor to transmit herewith annual reports * * * upon works of river and harbor improvement at present under my charge for the fiscal year ending June 30, 1896.

* * * * * * *

Very respectfully, your obedient servant,

JAMES B. QUINN,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

R 1.

IMPROVEMENT OF CHEFUNCTE (TCHEFUNCTE) RIVER AND BOGUE FALIA, LOUISIANA.

In 1880 the present project for the improvement of this river was adopted, contemplating the removal of obstructions in the channel consisting of snags, logs, and overhanging trees, and the dredging of the bar at the mouth.

Appropriations of $1,500 each were made in 1881 and 1882, and with these obstructions were removed, part of the 820 feet of breakwater was built, and a working plant for improving the bar at the mouth was constructed.

An appropriation of $2,500 was made August 5, 1886, and in 1887 work was commenced by cutting channels through the bars between Covington and Old Landing 5 feet deep and 60 feet wide, giving an improved navigation for schooners between these places.

The original estimated cost for improving the river was $5,460, the greater part being for dredging the bar at the mouth; it was deemed, however, that a dredged channel could not be maintained over the bar without protecting works which would cost considerably more than the dredging. Major Stickney, who had charge of the work, caused a reexamination to be made in 1884, and in his report in the Annual Report of the Chief of Engineers for 1884, Vol. II, page 1269, he reports the river in good order, except the bar at the mouth, and suggests as a method of improving this to build a jetty or breakwater 2,500 feet long across the bar into comparatively deep water of Lake Pontchartrain, and then to dredge the channel through the bar, in the hope that the jetty would prevent, or at all events greatly retard, the refilling of the cut with sand.

The work of removing obstructions from the channel was commenced in October, 1891, under the appropriation of $1,000 made in 1890, by the use of the snagging plant formerly used on Tickfaw River, consisting of quarter boat, flat supplied with derrick, steam hoisting engine for lifting out logs and snags, small boats, tools, etc., ordinarily used for this class of work. These obstructions were removed from the channel of the river from Covington to Madisonville, exhausting the funds, the obstructions removed being 161 snags, 82 overhanging trees, 61 landslide trees, 58 stumps, 44 logs, and 29 tree tops, the work being discontinued November 30, 1891.

An appropriation of $1,000 was made in 1892 for maintenance, but nothing was done other than the repair of snagging plant.

The total amount expended on the improvement to June 30, 1895, was $8,306.31, and the river then had a navigable depth of 5 feet to Old Landing, and the Bogue Falia was navigable for light-draft schooners from Old Landing to Covington.

The project under the appropriation of $1,000 for maintenance, made August 17, 1894, was to improve the navigation of these streams to the town of Covington, the only obstructions to which being a few bars with not over 3 feet depth over them. Accordingly, contract was entered into and approved in November, 1894, for the expenditure of available funds in dredging through the bars below Covington to a depth of 6 feet and a width of about 60 feet.

This work was commenced by the contractor February 4 and completed February 15, 1895, some 3,655 cubic yards of material being dredged from the bars.

Navigation is now available to Covington, about 14 miles from the mouth of the river, for steamers drawing 5 feet, and the bar at the mouth has a depth of about 5 feet at low water.

It is estimated that about $1,000 will be required annually to keep the rivers free of obstructions.

No work on this improvement was done during the fiscal year just ended.

There has been expended on this improvement to June 30, 1896, the sum of $8,330.29.

Abstract of appropriations for improving Chefuncte (Tchefuncte) River and Bogue Falia, Louisiana.

By act of Congress—	
Approved March 3, 1881	$1,500
Passed August 2, 1882	1,500
Approved August 5, 1886	2,500
Approved September 19, 1890	1,000
Approved July 13, 1892	1,000
Of August 17, 1894	1,000
Passed June 3, 1896	1,000
Total	9,500

Money statement.

July 1, 1895, balance unexpended	$193.69
Amount appropriated by act of June 3, 1896	1,000.00
	1,193.69
June 30, 1896, amount expended during fiscal year	23.98
July 1, 1896, balance unexpended	1,169.71
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	1,000.00

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	17
Trips	999
Net registered tonnage (999 trips)	74,623
Schooners	41
Trips	368
Net registered tonnage (368 trips)	10,467
Barges	8
Trips	121
Net tonnage (121 trips)	15,550
Total vessels	66
Total trips	1,488
Total tonnage (1,488 trips)	100,640

Draft of heaviest vessel—light, 5.2 feet; loaded, 7 feet.
No new lines of transportation were established.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
SHIPMENTS.				
Lumber, shingles, laths	32,039	$114,114	43,374	$192,071
Bricks	3,998	11,193	8,032	25,704
Sand	6,600	6,160	6,495	8,660
Wood	700	1,300	730	1,095
Cotton	648	73,574	306	47,320
Rice	518	16,788	141	1,987
Miscellaneous	288	3,312	7	335
Sheep, cattle, horses	31	1,662	74	7,000
Tar, rosin, turpentine	143	2,838	648	18,041
Sirup	165	4,990	24	936
Pecans	1	180	.....	.....
Moss	1	200	.....	.....
Wool	4	800	1	210
Total	45,136	237,111	59,838	303,859
RECEIPTS.				
Merchandise	4,544	113,000	7,940	317,595
Grand total	49,680	350,111	67,778	621,454

Comparative statement of receipts and shipments for seven years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1890	27,803	$173,283	1894	242,464	$919,699
1891	45,521	201,061	1895	49,680	350,111
1892	50,054	354,684	1896	67,778	621,454
1893	30,284	429,126			

R 2.

IMPROVEMENT OF TICKFAW RIVER AND ITS TRIBUTARIES, LOUISIANA.

An examination of these streams was made in 1879 by the authorization of Congress, and the estimated cost of the improvement was placed at $10,230, the project being to clean out the streams (Tickfaw, Natalbany, Blood, and Ponchatoula rivers) by removing obstructions from their channels, such as snags, stumps, logs, overhanging trees, etc., and placing them in a clear, navigable condition as far as possible. This project was submitted in 1881, and an appropriation of $2,000 was made in the same year for the work. Operations were commenced and completed in 1882, and resulted in the clearing of 16 miles of the channel of Tickfaw River.

In 1882 a further appropriation of $2,000 was made for the continuation of this improvement, part of this amount being expended in building a plant and the balance in the use of the plant and hired labor in cleaning out the river, with the result that a good navigable channel was obtained for 9 miles above the previous head of navigation on the Tickfaw River.

An appropriation of $2,000 was made in 1886 for the purpose of cleaning out the branches of the Tickfaw River, and this work was done by the use of the Government plant and hired labor in the latter part of 1886 and the early part of 1887, the branches being cleared out to the head of navigation.

An appropriation of $1,000 was made in 1888 for the continuation of this work, but as the branches were all in good condition, the work of removing the obstructions which had re formed in the river itself since 1887, was commenced in 1889, the work being carried on and completed upstream as far as the appropriations would permit, resulting in the improvement of 20 miles of the channel of the Tickfaw River from its mouth to within 1 mile of the Chapman Place.

Work was commenced in September, 1891, under the appropriation of $1,000 made in 1890 for the continuation of the improvement and was continued until October 12, 1891, this work consisting in the removal, by the Government plant and hired labor, of obstructions consisting of snags, logs, overhanging trees, etc., which had reformed since 1889, and resulted in the improvement of 30 miles of channel on the Tickfaw, Natalbany, and Blood rivers, the latter stream being cleared out to the head of navigation.

An appropriation for maintenance of $1,000 was made July 13, 1892, and the plant which had been used on the Amite River was towed to the Tickfaw, and work commenced December 20, 1892, and continued until January 20, 1893, 30 miles of channel being improved by the removal of 382 obstructions, the plant being laid up at Springfield, La., and placed in charge of a watchman at the conclusion of these operations.

The snagging plant used in the prosecution of this improvement, consisting of quarter boat for crew, flat supplied with derrick and steam

hoisting engine for pulling out snags, and small boats, tools, etc., ordinarily used for this work, was repaired in November, 1892.

On August 17, 1894, an appropriation of $1,000 was made for maintenance, and under this appropriation the snagging plant was thoroughly repaired, and work of removing obstructions which had re-formed was commenced in December, 1894, and continued until February 8, 1895, resulting in the removal of 1,568 obstructions, consisting of sunken logs, trees, etc., in a distance of 3½ miles, the improvement extending from Talbot's Field to Whitmore Island, on the Tickfaw River.

After the completion of this work the plant was removed to the Amite River for work there, and on completion of the work was tied up at Wadesboro and placed in charge of a watchman, and was subsequently sold at auction.

The total amount expended in the improvement of these streams to June 30, 1895, was $9,862.81.

Nothing has been done on this improvement during the fiscal year ending June 30, 1896, but with the appropriation of $1,000 made June 3, 1896, for maintenance, the improvement will be kept in good condition.

There was expended on this work during the fiscal year ending June 30, 1896, the sum of $13.33, making a total expended on the improvement of $9,876.14.

Abstract of appropriations for improving Tickfaw River and tributaries, Louisiana.

By act of Congress—	
Approved March 3, 1881	$2,000
Passed August 2, 1882	2,000
Approved August 5, 1886	2,000
Of August 11, 1888	1,000
Approved September 19, 1890	1,000
Approved July 13, 1892	1,000
Passed August 17, 1894	1,000
Passed June 3, 1896	1,000
Total	11,000

Money statement.

July 1, 1895, balance unexpended	$137.19
Amount appropriated by act of June 3, 1896	1,000.00
	1,137.19
June 30, 1896, amount expended during fiscal year	13.33
July 1, 1896, balance unexpended	1,123.86
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	1,000.00

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	4
Trips	130
Net registered tonnage (130 trips)	10,590
Schooners	27
Trips	156
Net registered tonnage (156 trips)	3,591
Total vessels	31
Total trips	286
Total net registered tonnage (286 trips)	14,181

Draft of heaviest steamer—light, 6 feet; loaded, 6.6 feet. Draft of heaviest schooner—light, 3 feet; loaded, 6 feet 4 inches.

No new lines of transportation were established.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
SHIPMENTS.				
Wood	5,495	$7,850	3,888	$7,776
Lumber	13,864	108,738	63,712	223,520
Brick	597	1,673	3,125	8,750
Cotton	182	21,120	246	38,000
Miscellaneous	61	1,560	.....	.....
Total	20,199	140,941	70,971	278,046
RECEIPTS.				
Merchandise	3,185	79,625	1,880	75,200
Grand total	23,384	220,566	72,851	353,246

Comparative statement of receipts and shipments for five years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1892	11,407	$102,116	1895	23,384	$220,566
1893	13,994	169,643	1896	72,851	353,246
1894	40,003	251,774			

R 3.

IMPROVEMENT OF AMITE RIVER AND BAYOU MANCHAC, LOUISIANA.

The original project, which contemplated a depth of channel of 5 feet as far upstream as appropriations would permit, principally above the mouth of the Bayou Manchac, was adopted in 1880, and was modified in 1883, owing to the unsatisfactory manner of doing the work by contract, so as to provide for the removal of obstructions below the mouth of the bayou by the use of the Government plant and hired labor. This resulted in the satisfactory improvement of 8 miles of the river.

The improvement was continued under the appropriation made in 1886, with the result that obstructions were removed from the river for a distance of 5 miles, placing the Amite River in a good navigable condition below the mouth of the bayou.

An appropriation of $5,000 was made in 1888, it being stipulated that one-half of the amount could be used in the improvement of Bayou Manchac. Work under the appropriation was commenced in November, 1888, with the Government plant and hired labor at the mouth of the bayou, and working up the bayou to Hereford Landing, leaving the channel of the bayou in a good navigable condition for that distance. The plant was then returned to the Amite River, where it was used in the removal of obstructions in the channel. A further appropriation of $3,800 was made in 1890, the amount to be applied to the Amite or Manchac, at the discretion of the engineer in charge. Work was commenced in October, 1890, and obstructions removed from the Amite

River to the mouth of the bayou and from the bayou between its mouth and Hope Villa.

An appropriation for maintenance of $2,500 was made in 1892, $1,000 being intended for the construction of a turning basin for boats at the mouth of Wards Creek on the bayou, but as the amount was not deemed sufficient, on recommendation it was held for increase.

Authority having been obtained, the snagging plant, consisting of a quarter boat, derrick boat with steam hoisting engine, etc., and tools ordinarily used in this class of work, was thoroughly repaired and work commenced November 17, 1892, and continued until December 15, 1892, improving 20 miles of channel from Wards Creek, on Bayou Manchac, to Port Vincent, on the Amite River, 381 obstructions being removed. On the completion of this work the plant was towed to the Tickfaw River for use on that stream.

August 17, 1894, an appropriation of $2,500 was made for maintenance, the approved project under which contemplated the removal of obstructions from the river and bayou and the expenditure of the $1,000 appropriated in 1892 in dredging a turning basin.

Dredging of the turning basin was commenced January 24 and completed February 1, 1895, 4,080 cubic yards of material and numerous logs being removed.

The snagging plant was returned from the Tickfaw River, and after being repaired work was commenced at the mouth of Wards Creek on the bayou and continued down to the town of Clio, on the Amite River, a distance of 22 miles, and having continued from February 18 to May 31, 1895, 5,019 obstructions, consisting of landslide trees, sunken logs, snags, brush, and overhanging trees, being removed, and 1,852 trees deadened.

The improvement gave great relief to commerce by adding an average of 3 feet to the available depth of the channels, also increasing the width very materially.

As obstructions continue to re-form the improvement is not permanent, and it is estimated that $2,500 will be required annually to keep the streams in navigable condition.

The amount expended on these streams to June 30, 1895, was $28,279.32.

By the authority of the Secretary of War dated December 27, 1895, the engineer property pertaining to this improvement was sold at public auction, after thirty days' public notice, on March 30, 1896, at Wadesboro, La.

As shown by the commercial statistics for the year ending June 30, 1896, the commerce involved in this improvement amounts to $414,245. There has been expended on the improvement to June 30, 1896, the sum of $28,473.63.

Abstract of appropriations for improving Amite River and Bayou Manchac, Louisiana.

By act of Congress—	
Approved June 14, 1880	$8,000
Approved March 3, 1881	5,000
Approved August 5, 1886	2,000
Of August 11, 1888	5,000
Approved September 19, 1890	3,800
Approved July 13, 1892	2,500
Of August 17, 1894	2,500
Passed June 3, 1896	2,500
Total	31,300

Money statement.

July 1, 1895, balance unexpended	$520.68
Amount appropriated by act of June 3, 1896	2,500.00
	3,020.68
June 30, 1896, amount expended during fiscal year	194.31
July 1, 1896, balance unexpended	2,826.37
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	2,500.00

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	7
Trips	271
Net registered tonnage, 271 trips	19,368
Schooners	28
Trips	125
Net registered tonnage, 125 trips	3,268
Barges	4
Trips	154
Net tonnage, 154 trips	3,080
Total vessels	39
Total trips	550
Total net tonnage, 550 trips	25,716

Draft of heaviest vessel—light, 6½ feet; loaded, 7 feet.
No new lines of transportation were established.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
SHIPMENTS.				
Lumber, shingles, laths	33,303	$223,456	45,081	$155,404
Wood	3,676	5,973	5,062	10,124
Staves	522	18,118	1,028	18,636
Sugar and molasses	251	9,373	221	15,345
Cotton and cotton seed	1,503	111,726	928	104,480
Miscellaneous	65	5,995	79	2,096
Total	38,320	374,641	52,399	306,085
RECEIPTS.				
Merchandise	4,663	116,575	2,704	108,160
Grand total	42,983	491,216	55,103	414,245

Comparative statement of receipts and shipments for seven years.

Year ending May 31—	Tons.	Value.	Year ending May 21—	Tons.	Value.
1890	84,295	$291,967	1894	157,902	$796,305
1891	17,792	300,963	1895	42,983	491,216
1892	18,530	334,061	1896	55,103	414,245
1893	22,099	346,257			

R 4.

IMPROVEMENT OF BAYOU LAFOURCHE, LOUISIANA.

The first project for the improvement of the bayou was approved in 1879, having for its object the removal of obstructions consisting of snags, logs, wrecks, etc., and work under this project was carried on from 1881 to 1883, clearing the bayou for a distance of 30 miles below Lockport, at which point the plant with which the work was done was laid up.

Another project was approved in 1884 and under this the snagging operations were resumed September, 1884, and carried on until January, 1885, operations being suspended on account of high water and the plant being removed to other places.

Nothing was done on this work beyond surveys and examinations until 1888, in which year Congress appropriated $50,000 for the improvement of Bayou Lafourche, Louisiana, under the project of Lieut. O. T. Crosby, Corps of Engineers, dated June 11, 1886, including immediate dredging to secure low-water navigation.

During high water the bayou is navigable for the largest river steamers, but during the extreme low-water period navigation is entirely suspended for flatboats drawing more than 2 feet of water.

Lieutenant Crosby's project had for its object the establishment of a lock at the head of the bayou at its junction with the Mississippi River, rendering the bayou a slack-water stream, then to establish a channel 75 feet wide and 5 feet deep at mean low water of the Gulf the entire length of the bayou by dredging. It was estimated that the lock would cost $450,000, but with the establishment of the lock it is believed that the work which now has to be gone over each year on account of the silting up of the dredged channel which takes place with the recurrence of each high water would be rendered permanent, and the benefits accruing to the commerce using this route would be such as to pay for the cost of the lock in a few years, represented in the saving to producers, consumers, and carriers. This would also render the navigation of the bayou independent of the stage of water in the Mississippi River and would give a steamboat service to the trade on the bayou all the year round. There is a very strong popular sentiment in favor of the establishment of the lock.

Under the appropriation of $50,000 made in 1888 dredging was commenced on the bar at the mouth of the bayou which had completely excluded navigation in 1887, and a channel 4 feet deep and 60 feet wide was dredged through this bar, admitting sufficient water to reestablish navigation by flats which had been suspended a day or two while the cut was being made. The dredging was done by contract.

It was estimated that 150,000 cubic yards of material would have to be dredged from the channel of the bayou in order to secure 2 feet depth for flatboat navigation, and proposals for doing this work were submitted June 10, 1889, but being considered too high were rejected, and the work done with a hired dredge, being continued until high water, at which time a depth of between 2 and 3 feet had been secured for a distance of 2 miles from the mouth of the bayou. Upon the commencement of the work it was found that the channel through the bar had shoaled and had to be redredged, and owing to the caving of the sides of the cut much of the channel work had to be gone over several times.

Operations were resumed September 15, 1890, the channel through the bar at the head of the channel having to be redredged, the same

being the case with a majority of the dredging formerly done. The dredging operations have been continued since during the low-water season of each year, and in 1892, with the use of an additional dredge, the work was carried on from Donaldsonville to the mouth of the bayou, improving 100 miles of channel.

During the low-water season of 1893 operations were continued between Donaldsonville and a point 2 miles above Lockport.

The work was continued between July 5, 1894, and April 5, 1895, improving the bayou from its mouth to a point 33 miles below Donaldsonville, and rendering flatboat navigation available during the entire low-water season.

There has been expended on this work, to June 30, 1895, the sum of $141,930.80.

After due advertisement, contract was entered into with Mr. E. A. Burriss, of New Orleans, La., July 9, 1895, and approved July 16, 1895, and work under this contract was commenced July 20, 1895.

Owing to the conditions prevailing, it became necessary to place another dredge on this bayou, and contract was entered into with Mr. Henry Camors, New Orleans, La., August 9, 1895, and approved August 16, 1895, and work with the additional dredge was commenced August 23, 1895.

Operations were carried on to March 16, 1896, when they were stopped owing to high water, resulting in the removal of 164,047 cubic yards of material, 498 logs, 288 stumps, 4 flatboat wrecks, and 1 old boiler, and affording great relief to navigation.

Under date of June 16, 1896, contract was entered into with Mr. Henry Camors, New Orleans, La., for furnishing dredge for the continuation of this improvement, and under this contract it is expected that operations will be commenced at an early date.

There has been expended on this improvement to June 30, 1896, the sum of $168,857.92.

Abstract of appropriations for improving Bayou Lafourche, Louisiana.

By act of Congress—	
Approved June 18, 1878	$10,000
Approved March 3, 1879	10,000
Approved June 14, 1880	5,000
Approved July 5, 1884	5,000
Of August 11, 1888	50,000
Approved September 19, 1890	50,000
Approved July 13, 1892	50,000
Of August 17, 1894	40,000
Passed June 3, 1896	25,000
Total	245,000

Money statement.

July 1, 1895, balance unexpended	$78,069.20
Amount appropriated by act of June 3, 1896	25,000.00
	103,069.20
June 30, 1896, amount expended during fiscal year	26,927.12
July 1, 1896, balance unexpended	76,142.08
July 1, 1896, amount covered by uncompleted contracts	11,123.00
July 1, 1896, balance available	65,019.08
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	* 25,000.00

* The estimate submitted is for maintenance, $25,000 being required annually.

Abstract of proposals for furnishing dredge for improving Bayou Lafourche, Louisiana, opened by Maj. James B. Quinn, April 30, 1896.

No.	Name and address of bidder.	Price per day of 8 hours.
1	Ethan Allan Burriss, New Orleans, La	$59
2	Henry Camors, New Orleans, La	49

The bid of Mr. Henry Camors was accepted, and contract entered into with him July 2, 1896.

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	25
Trips	520
Net registered tonnage (520 trips)	80,960
Luggers	31
Trips	53
Net tonnage (163 trips)	123,394
Total vessels	219
Total trips	736
Total net tonnage (736 trips)	204,778

Draft of heaviest steamer, light, 3 feet; loaded, 9 feet. Draft of heaviest barge, light, 18 inches; loaded, 8 feet.

No new lines of transportation were established.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
SHIPMENTS.				
Sugar	88,376	$6,823,122	44,606	$3,143,209
Molasses	31,322	569,688	20,158	439,917
Rice	2,320	83,294	4,107	69,447
Potatoes and onions	5,779	115,587	7,723	178,451
Eggs	156	23,395	218	21,154
Moss	168	6,732	431	17,263
Pecans	30	4,848	3	420
Miscellaneous	214	10,496	347	28,115
Total	128,375	7,637,162	77,593	3,897,976
RECEIPTS.				
Miscellaneous	50,632	1,314,792	32,688	1,306,381
Coal	84,600	272,600	119,610	425,280
Grand total	263,607	9,224,554	229,891	5,629,237

Comparative statement of receipts and shipments for seven years.

Year ending May 31—	Tons.	Value.	Year ending May 1—	Tons.	Value.
1890	200,746	$5,709,382	1894	273,686	$8,842,942
1891	217,273	8,244,225	1895	263,607	9,224,554
1892	171,885	5,660,662	1896	229,891	5,629,237
1893	212,476	7,422,285			

R 5.

IMPROVEMENT OF BAYOU PLAQUEMINE, GRAND RIVER, AND PIGEON BAYOUS, LOUISIANA.

Up to 1867 or 1868 the bayou was navigable for the largest steamers, but at some period during these years the police jury of Iberville Parish caused a dike to be built across the bayou, shutting out the waters of the Mississippi River, and steamers which had formerly used the Bayou Plaquemine route were forced to the Teche and Courtableau by way of Red River and Atchafalaya, and are compelled to cease running altogether during low water, as the mouth of the Red River is closed at that time.

The opening of this route is of great importance, therefore, as it will afford a means of communication at all times of the year with the navigable waters of North Louisiana, which are estimated, by good authority, to have a length of 4,300 miles.

In 1885 a project for the improvement of this bayou was submitted, providing for the building of a lock connecting it with the Mississippi River and clearing out the channel so as to give a depth of 6 feet at mean low water of the Gulf, the improvement being estimated to cost $1,708,250.

An appropriation of $100,000 was made in 1888 "for securing a navigable channel 60 feet wide and 6 feet in depth from deep water up to the Plaquemine Dike, and for securing the mouth of the bayou from further caving."

As this office had no plant at its disposal for the construction of dikes, etc., $75,000 was allotted for construction of bank protection and turned over to the officer in charge of the fourth district of the Mississippi River in May, 1889, and with the remainder of the funds the work of dredging was commenced at a point 5 miles below the town of Plaquemine, with the Government dredge and hired labor, June 4, 1889; but owing to the railroad bridge not being a drawbridge, it was not possible to continue the dredging past it up to the Plaquemine Dike, and the project was, therefore, amended so as to stop dredging when the railroad bridge was reached. Dredging was carried on up to the bridge and the dredge then turned back, making a second cut down to one-half mile below, the plant being then laid up and placed in charge of a watchman.

While in charge of the watchman the dredge sank August 20, 1892, but she was raised again September 5 and given a general overhauling, the repairs being completed November 20, 1892, after which date the boat was employed in improving the bayou, all obstructions being removed for a distance of 3½ miles, the work ceasing January 1, 1893.

August 17, 1894, an appropriation of $110,000 was made for continuing the improvement, of which the sum of $10,000 was allotted for the removal of obstructions in Grand River and Pigeon bayous, a part of the Plaquemine route.

A project was approved for the expenditure of the above appropriation, together with available balance from previous appropriations, contemplating the continuance of dredging in Bayou Plaquemine, construction of cofferdam and proposed lock, and the removal of obstructions in Grand River and Pigeon bayous, the sum of $20,000 being reserved for repairs to the river bank protection.

Dredging operations were resumed in Bayou Plaquemine January 11, 1894, and continued until November 5, 1894, when the dredge was taken to the work on Grand River and Pigeon bayous.

The dredging work was carried on between the railroad bridge and Plaquemine Dike.

The amount of material removed from Bayou Plaquemine by the dredge since the commencement of the improvement is 355,921 cubic yards and 2,081 logs, snags, stumps, etc. The character of the material dredged required the construction of bulkheads in order to keep it from slipping back into the bayou.

GRAND RIVER AND PIGEON BAYOUS.

The act of July 13, 1892, provided that these streams be improved as part of the Bayou Plaquemine route, and the dredge was ordered to Grand River January 1, 1893, work being continued between Sorrel Bayou and Pigeon Bayou until March 22, 1893, operations being suspended at this time on account of the rise in the river, and the dredge proceeding to Flat Lake at the lower end of the Grand River, the object being to open up the route to the Teche and Atchafalaya via Grand River.

The operations in Grand River resulted in the removal of 13,826 cubic yards of material, 5,525 overhanging trees, 667 logs, 16 snags, and 55 stumps.

In 1893, obstructions were removed from the mouth of Bayou Sorrel, and down Grand River through Big Pigeon Bayou to Grand Lake, a distance of 30 miles, the obstructions removed consisting of 1,386 overhanging trees, 98 sunken logs, and 4½ miles of raft, the work being carried on from August 17 to October 2, 1893.

The sum of $10,000 being provided by the act of August 17, 1894, for the removal of obstructions from these bayous, authority was obtained for the hire of the dredge at work on Bayou Plaquemine, and on completion of the work there, November 5, 1894, the dredge was removed to the junction of Sorrel and Grand River bayous and the work was carried on from this point to the mouth of Little Pigeon Bayou via Grand River and Big Pigeon bayous, practically the same route gone over in 1893. The work was discontinued January 3, 1895, on account of the funds being exhausted. The bar at the entrance to Grand Lake being composed of very hard material, the channel was not completed through it.

Authority was obtained and the dredge operated double time during a portion of the period employed, as it was greatly desired to complete the clearing of the streams before the recurrence of high water.

The operations resulted in the removal of 32,535 cubic yards of material, 133 stumps, 495 sunken logs, and 36 overhanging trees, in a distance of about 30 miles.

By the completion of this route a competing steamboat connection is opened in connection with the Texas and Pacific Railway at Plaquemine, causing a reduction of freight rates from the Teche amounting to 33⅓ per cent.

The total amount expended on this improvement thus far is $18,698.91, and in order to keep the route open $10,000 could be profitably expended during the coming year.

PLAQUEMINE LOCK.

In 1890 an appropriation of $100,000 was made for continuing the improvement of Bayou Plaquemine, of which $60,000 was allotted for completing bank-protection work on the Mississippi River and $40,000

was allotted to this office, and under the last allotment a project for commencement of work upon a lock connecting the Mississippi River with the bayou was presented, a board of engineer officers being appointed to consider the subject. Under this Board plans for a lock of sufficient size to pass four coal boats or the largest steamers liable to make use of the lockage were prepared.

In 1892 an appropriation of $150,000 was made with a proviso that $10,000 of this amount be used in the discretion of the Secretary of War in removing obstructions from Grand River and Pigeon bayous, a part of the Plaquemine route, and for securing the bank protection an allotment of $72,000 was made from this appropriation and was expended as in former cases.

The amount remaining was not considered sufficient to warrant the commencement of the work on the lock, and it was held subject to an increase, the estimated cost of the lock and approaches being $700,000.

Title to the lands expropriated by the United States for the lock were obtained in 1893 at a cost, including court charges, of $34,993.23. The buildings located on the property were sold at public auction for the sum of $2,070.05, the amount being deposited to the credit of the Treasurer of the United States.

Under the appropriation of August 17, 1894, the project approved contemplates the construction of a cofferdam to surround the site and excavating and piling foundation of lock, the amount available for the work being $114,200.

Contract was entered into June 24, 1895, for construction of cofferdam and excavating and piling foundation for lock, the consideration being $93,250.

Under this contract work was commenced September 1, 1895, and has been continued actively since, resulting in the removal of 83,000 cubic yards of earth. The cofferdam is completed with the exception of a small gap left for the passage of the dredge. Five hundred and ninety of the foundation piles have been driven.

During the recent rise in the Mississippi River the surface of the water in that stream was for several weeks about 27 feet above the level of the excavation, but although the distance intervening is only 450 feet no seepage took place.

The material excavated below low-water mark is blue clay and almost impervious to water. The foundation for the lock promises to be easily and securely attained.

SECURING MOUTH OF BAYOU PLAQUEMINE FROM FURTHER CAVING.

This work, placed in charge of the officer of the fourth district of the Mississippi River in May, 1889, was retransferred to this office September 28, 1894, after having been completed.

In 1888 an allotment of $75,000 was made for the bank protection work from the appropriation for improving Bayou Plaquemine, being intended to secure the site of the lock proposed to be built.

The original plan under which the work had been prosecuted contemplated the construction of a series of spur dikes normal to the bank line, placed at intervals of 700 to 1,200 feet along the caving bank, the dikes being 400 feet long and 150 wide, and built of brush and stone, the plan being similar to that formerly employed for the works of bank protection in New Orleans Harbor.

Five dikes constructed as above were completed, two below and three above the entrance to the proposed lock, but as caving of the bank con-

tinued preparations were made to make certain repairs to the work during the low-water season of 1893, but the caving reached such an extent it became evident effective repairs could not be made available with detached spur dikes alone, and a project was therefore proposed for constructing continuous revetment between the dikes, estimated at $72,000 in addition to the balance on hand.

This project was approved and the amount asked allotted, and under this project continuous revetment has been laid, which, with the spur dikes, forms a continuous protection 1,400 feet long below the site of the lock and 1,200 feet above, with an interval of 500 feet opposite the lock site left for excavating the necessary channel to the lock.

The revetment has an average width of 400 feet.

The sum of $20,000 was allotted for bank-protection work from the appropriation of August 17, 1894, for improving Bayou Plaquemine.

Nothing has been done during the past year on the bank-protection work, although the bank at the mouth of the bayou commenced to cave September 5, 1895, and the caving continued steadily but without making a great deal of progress.

Authority was secured for publishing advertisements soliciting bids for building and placing mattresses for the purpose of stopping the caving, but owing to the high water no bids were received. As soon as low-water season sets in and the extent of the caving can be ascertained the work will be readvertised and the bank placed in a secure condition.

With the exception of this caving, the revetment work is in good condition.

The results to follow the placing of locks in Bayou Plaquemine can not be judged in the present showing of tonnage and commerce, but are to be determined by the advantages their completion will exercise upon the agricultural and commercial interests of a very large, populous, and highly productive section of country, embracing the great sugar and rice producing parishes of Iberville, St. Landry, St. Martin, Iberia, St. Mary, Lafayette, Vermillion and Terrebonne, which will then become possessed of another but more convenient and better competitive route of shipment.

The Atchafalaya River, Bayous Grossetete, Teche, Vermilion, Terrebonne, and other streams will be then given such a certain, nearer connecting link with the Mississippi River and the city of New Orleans that employment will be offered to vessels, not now to be had because of the long, difficult, and expensive all-water route via the Atchafalaya River. For years, and since Bayou Plaquemine was closed by a dam, steamboats went to the Teche and Vermilion by that route, but the distance was so great and the shoals in the La Rompe and Lake Chicot were such troublesome, expensive obstacles to contend with that the route has been finally abandoned, and now the railroad is without a competitor. Ten days were occupied in making the round trip, but by way of the locks that time will have been shortened to six days and under, making an all-water communication with New Orleans and the great markets of the West, so certain and easily accessible at all times, as will lower the present transportation rates for producers and consumers in an amount the sum total of which can now hardly be computed, but an idea of which can be formed by this year's tonnage and commercial showing of the Teche, Vermilion, and Plaquemine, amounting to 400,127 tons, valued at $4,893,679, and upon every dollar of which there will be an appreciable saving. The Pittsburg coal for this sugar section now goes by the way of the Atchafalaya River; its towage

is expensive because of the distance and risks, and not infrequently its cost is largely added to by having to lighter over the La Rompe (last year thousands of dollars having been lost that way). This year's supply amounted to 100,590 tons, valued at $407,340. Could this coal have gone by the locks the difference in distance and time, in risks and insurance, and in the avoiding of lighterage, would have insured its delivery at a cost to the consumers far below this valuation.

The total amount expended on this improvement to June 30, 1896, was $359,412.76.

Abstract of appropriations for improving Bayou Plaquemine, Louisiana.

By act of Congress—	
Of August 11, 1888	$100,000
Approved September 19, 1890	100,000
Approved July 13, 1892	150,000
Of August 17, 1894	110,000
Of June 3, 1896	20,000
	480,000

Money statement.

July 1, 1895, balance unexpended		$150,297.27
Amount appropriated by act of June 3, 1896		20,000.00
		170,297.27
June 30, 1896, amount expended during fiscal year		49,710.03
July 1, 1896, balance unexpended		120,587.24
July 1, 1896, outstanding liabilities	$4,867.50	
July 1, 1896, amount covered by uncompleted contracts	44,625.00	
		49,492.50
July 1, 1896, balance available		71,094.74
Amount (estimated) required for completion of existing project		1,228,250.00
Amount that can be profitably expended in fiscal year ending June 30, 1898		500,000.00

Submitted in compliance with requirements of section 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	9
Trips made	276
Net registered tonnage (276 trips)	11,942
Barges	4
Trips made	264
Net tonnage (264 trips)	33,000
Total vessels	13
Total trips	540
Total net tonnage (540 trips)	44,942

Draft of heaviest vessels—light, 3 feet; loaded, 4 feet.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
Sugar and molasses	7,119	$631,520	183	$3,363
Moss	7	268	.....	.....
Miscellaneous	5,781	181,019	2,438	68,622
Cotton seed and cotton	53	1,448	346	17,110
Lumber, shingles, etc	107,582	295,875	89,412	195,080
Total	120,542	1,110,130	92,379	284,175

Comparative statement for five years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1892	131,875	$1,343,608	1895	120,542	$1,110,130
1893	78,756	1,174,750	1896	92,379	284,175
1894	133,752	555,677			

R 6.

IMPROVEMENT OF BAYOU COURTABLEAU, LOUISIANA.

A project was approved in 1879 having for its object the removal of the bar obstructing the mouth of the bayou by concentrating the waters of the Courtableau upon it, this to be accomplished by closing the run-out bayous and confining the water in the main channel of the Courtableau. After this was accomplished to construct locks and dams so as to give slack-water navigation first to Port Barre, a distance of 17 miles upstream and then to Washington, La., 11 miles farther up.

The preliminary estimate for the cost of the work was $40,000, which was afterwards increased to $78,500, and in the Annual Report of 1886 it was estimated that the cost of a masonry lock and dam would be $175,000.

Dams were built on the Big and Little Fordoche bayous in 1882, and timber was cut into the smaller bayous so as to concentrate the flow of water in the main channel of the Courtableau, in order to wash out Little Devil Bar, with the result of an increase of 3 feet in the depth of water over the bar in two days.

It was reported that swampers cut one of these dams and the bar afterwards shoaled up. In 1885 the cut dam was rebuilt and the other dam repaired. A sudden rise caused one of the dams to break, but it was repaired, and good results were hoped for during the following summer, but in 1886 the Courtableau was very low and the bar at the mouth shoaler than ever, it being impossible to float a skiff over the bar at the lowest stage.

Lieutenant Crosby made an examination of this stream in September, 1886, and from his report (Annual Report Chief of Engineers for 1887, p. 1376), the prospects of success even with all the run-out bayous closed were uncertain, notwithstanding the closing of two of the principal outlets in one season did produce an increase of 3 feet depth of water. In view of this fact, and that the project called for the closing of the bayous, the work was again resumed in 1886 with money appropriated in August of that year, the dams already built being repaired and another built at the mouth of English Bayou, and Bayou Mamzelle being also closed, the result being that a channel 3 to 5 feet deep where there had been but a few inches of water. However, the channel procured was of no use, as the closing of Old River stopped the passage of boats from the Mississippi into the Atchafalaya River.

Under the action of high water the bar formed again in 1888, a deposit of 6 to 8 feet of sand being made over a distance of 2 miles.

From a personal examination made in 1888 by Captain Fisk, during low water, it was observed that the preceding high water had cut around one end of each of the dams already built, but had caused a sand bar to form at each, varying in height from 2 to 3 or 4 feet above the water in the Courtableau at the time of the examination, thus forcing all the water in the bayou to pass out into the Atchafalaya across Little Devil Bar, the head of which was then some 300 or 400 feet above the Little Fordoche. The volume of water swelled by heavy

local rains caused a swift current which moved large quantities of sand, as could be seen, but the depth at the shoalest point could not have been more than 18 inches.

It is believed that had the bar been removed to a sufficient depth there would not have been sufficient water left in the bayou above for purposes of navigation.

As soon as possible after high water in 1888 preparations were made to repair the dams and to build others, also for closing some of the remaining outlets, but the water rose again before the plant to be used on the work could be put in repair, and the work was not resumed until September 2, 1889, when the broken dams were repaired and left in good condition, and bayous Big and Little Cane were obstructed by cutting trees into them, and the plant was then taken to Bayou Juramon, but the water rose rapidly and the plant and material were taken to Washington and laid up, and nothing was done beyond some slight repairs to the derrick boat until low-water season of 1891, when the dams were all thoroughly repaired with piles and sheet piles and brush aprons, being left in good condition, the plant being laid up November 20, at Washington, La.

It is doubted that the completion of the project will result in the permanent removal of Little Devil Bar, as it is certain to re-form at each high water in the Atchafalaya River.

An appropriation of $5,000 was made August 17, 1894, for continuing this improvement, the approved project under the appropriation looking to the closure of bayous Fordoche, Mamzelle, Big and Little Cane, and if funds would permit to close the small bayous between bayous Mamzelle and Big Cane. Bids for furnishing a suitable plant for this work were opened June 27, 1895, the contract being approved July 17, 1895, and work carried on from August 8 to November 9, 1895, completing the project and leaving the work in good condition.

It being reported to this office that the channel of Bayou Courtableau was obstructed by a raft of logs coming in from the Atchafalaya River and down the Courtableau, authority for the expenditure of the balance remaining to the credit of this appropriation was approved by the Chief of Engineers February 28, 1896, in the removal of this raft.

Posters and circular letters were issued providing for the clearing of a navigable channel through the raft, as the balance to the credit of the appropriation was too small to entirely remove the raft, which is about 2½ miles in length.

The work of making a navigable channel through the raft was awarded to Mr. Chas. H. Smith, of New Orleans, La., for $440, with the understanding that nothing was to be paid him unless he was successful in securing the channel. Some attempts to do the work were made by the contractor, but the raft accumulated faster than he could remove it and he abandoned the work. The bayou is now completely blocked and traffic on same suspended.

It is estimated that about $5,000 will be required to clear the raft from the bayou and leave it free of the drift, etc.

To June 30, 1896, there had been expended on this improvement the sum of $35,425.61.

Abstract of appropriations improving Bayou Courtableau, Louisiana.

By act of Congress—		By act of Congress—	
Approved June 14, 1880	$7,500	Approved September 19, 1890	$2,200
Approved March 3, 1881	7,500	Passed August 17, 1894	5,000
Approved July 5, 1884	4,000	Passed June 3, 1896	2,500
Approved August 5, 1886	5,000		
Passed August 11, 1888	5,000	Total	38,700

Money statement.

July 1, 1895, balance unexpended	$5,141.02
Amount appropriated by act of June 3, 1896	2,500.00
	7,641.02
June 30, 1896, amount expended during fiscal year	4,366.63
July 1, 1896, balance unexpended	3,274.39
Amount that can be profitably expended in fiscal year ending June 30, 1898	5,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	1
Trips	26
Net registered tonnage, 26 trips	6,292

Draft of vessel—light, 2 feet; loaded, 5 feet.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
SHIPMENTS.				
Sugar and molasses	473	$20,523	312	$19,704
Rice	298	10,659	78	2,090
Cotton and cotton seed	1,604	87,928	234	26,650
Miscellaneous	100	7,177	70	3,500
Total	2,475	126,287	694	51,944
RECEIPTS.				
Merchandise	1,620	40,500	1,300	52,000
Grand total	4,095	166,787	1,994	103,944

Comparative statement of receipts and shipments for seven years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1890	35,867	$4,629,584	1894	9,195	$485,811
1891	32,618	3,917,344	1895	4,095	166,787
1892	20,041	994,471	1896	1,994	103,944
1893	14,848	677,529			

R 7.

IMPROVEMENT OF BAYOU TECHE, LOUISIANA.

Prior to 1886 logs, snags, and impending trees obstructed the channel of this bayou, which is ordinarily navigable by steamers throughout the year, but in that year an appropriation was made and the channel cleared from Port Barre down, and under the appropriation of $5,000 made in 1890 obstructions which had formed since 1886 were removed, operations extending from St. Martinville to a point about 59 miles below, the work covering a period from October to December 10, 1891,

the obstructions removed consisting of 238 snags, 144 piles, 98 overhanging limbs, 36 overhanging trees, 30 fallen trees, 50 sunken logs, 18 floating logs, and 37 stumps.

Shoals having formed since the improvement in 1891, under the appropriation of $6,000 made August 17, 1894, for continuing improvement, these shoals were dredged out under contract, the work covering a period of time from February 4 to May 7, 1895, exhausting the funds and improving about 70 miles of channel from Franklin below, the operations consisting in the removal by dredging of 98,250 cubic yards of material, 215 sunken logs, 6 snags, 38 stumps, 3 wrecks, and 39 overhanging trees, the channel through the bars being dredged to a depth of 8 feet at low water and a width of fully 50 feet.

The improvement can not be considered as permanent, as wrecks of coal boats, logs, and fallen trees are continually forming obstructions which will require removal.

Business men of all classes interested in this route, forming a part of the Plaquemine water route, expressed much satisfaction with the dredging work done on the bayou, and state that after the completion of the work the bayou was in a much better navigable condition than it had been for years.

Much of the trouble caused by the drainage of the large sugar mills, refineries, cane fields, etc., was removed by the dredging done, but further dredging will be required and will be carried on with the appropriation of $10,000 made by Congress on June 3, 1896. A project for the work will be formulated and forwarded at an early date, and under this project work will be commenced.

This is a very important improvement, and the benefits which will arise from the opening of the locks at Bayou Plaquemine, and the connection by this means with New Orleans, are almost incalculable, causing a reduction in freight rates and affording extra and certain facilities for a quick marketing of the crops.

The value of commerce involved in this improvement is $4,254,368, as shown by the commercial statistics appended. There has been expended on the improvement to June 30, 1896, the sum of $60,972.56.

Abstract of appropriations for improving Bayou Teche, Louisiana.

By act of Congress—	
Approved July 11, 1870	$17,500
Approved June 14, 1880	6,000
Approved March 3, 1881	20,000
Approved July 5, 1884	6,500
Approved September 19, 1890	5,000
Passed August 17, 1894	6,000
Passed June 3, 1896	10,000
Total	71,000

Money statement.

July 1, 1895, balance unexpended	$65.62
Amount appropriated by act of June 3, 1896	10,000.00
	10,065.62
June 30, 1896, amount expended during fiscal year	38.18
July 1, 1896, balance unexpended	10,027.44
Amount that can be profitably expended in fiscal year ending June 30, 1898	15,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	29
Trips	807
Net registered tonnage (807 trips)	69,508
Barges	115
Trips	519
Net tonnage (519 trips)	157,730
Total vessels	144
Total trips	1,326
Total net tonnage (1,326 trips)	227,238

Draft of heaviest vessel—light, 2½ feet; loaded, 8 feet.
No new lines of transportation were established during the year.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
SHIPMENTS.				
Sugar	50,402	$4,230,885	35,409	$2,964,179
Molasses	6,062	109,450	3,513	77,749
Rice	559	17,534	338	5,817
Potatoes and onions	14	315	.....	.....
Eggs	30	4,594	.....	.....
Moss	34	1,354	28	1,110
Pecans	5	690	5	612
Hides	8	1,066	15	1,770
Cotton and cotton seed	1,843	18,810	468	10,910
Cotton-seed oil	210	840	115	6,420
Wood	12,985	18,620	7,236	21,670
Miscellaneous	30,753	209,157	7,236	21,670
Total	102,905	4,613,115	55,424	3,096,580
RECEIPTS.				
Machinery, merchandise, coal, saw logs, etc	177,023	1,181,368	239,322	1,157,788
Grand total	279,928	5,794,483	294,746	4,254,368

Comparative statement of receipts and shipments for four years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1891	26,905	$1,715,026	1894	383,154	$7,378,789
1892	64,866	833,110	1895	279,928	5,794,483
1893	115,080	5,754,542	1896	294,746	4,254,368

R 8.

IMPROVEMENT OF CHANNEL, BAY, AND PASSES OF BAYOU VERMILION, LOUISIANA.

A preliminary examination was made of the channel, bay, and passes in 1891, and a project was approved in 1892 providing for the removal of obstructions in the bayou, and the marking of the channel in the bay by means of guide piles, the estimated cost being $25,000, and under this project an appropriation of $7,500 was made July 13, 1892.

Proposals for a suitably equipped steamboat for doing this work were opened October 7, 1892, the plant secured consisting of a stern-wheel steamer with a crew of 14, and supplied with a steam capstan, winch,

derrick, blocks and tackle, and also pile driver for driving the guide piles in the bay, and work with this plant was commenced December 1, 1892, at a point 18 miles above the mouth of the bayou, the snagging part of the contract being completed March 9, 1893, the improvement covering 37½ miles of channel by the removal of 3,032 obstructions.

The driving of the guide piles in Vermilion Bay was not completed until July 31, 1893, an extension of time having been granted to the contractor owing to the delay caused by the loss of his boat.

An appropriation of $5,000 was made August 17, 1894, for the continuation of this improvement, the project for the expenditure of the funds providing for the clearing of the stream above Abbeville for a distance of 30 miles, or as much thereof as may be possible with the funds available.

A suitably equipped steamboat was hired under contract approved May 3, 1895, and operations were commenced by the contractor June 3, 1895, and completed August 27, 1895, resulting in the improvement of about 26 miles of channel by the removal of 78 snags, 143 submerged logs, 54 stumps, and 1,211 overhanging trees.

This forms also a part of the all-water route via Plaquemine, La., and all parties interested in shipping or receiving freight are anxious for the opening of the locks at Bayou Plaquemine, as all freight rates will be cheapened.

The amount expended on this improvement to June 30, 1896, was $12,365.63.

Abstract of appropriations for improving channel, bay, and passes of Bayou Vermilion, Louisiana.

By act of Congress—	
Approved July 13, 1892	$7,500
Passed August 17, 1894	5,000
Passed June 3, 1896	1,000
Total	13,500

Money statement.

July 1, 1895, balance unexpended	$5,418.93
Amount appropriated by act of June 3, 1896	1,000.00
	6,418.93
June 30, 1896, amount expended during fiscal year	5,284.56
July 1, 1896, balance unexpended	1,134.37
Amount (estimated) required for completion of existing project	11,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	11,500.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	6
Trips	193
Net registered tonnage (193 trips)	3,307
Barges	4
Trips	181
Net tonnage (181 trips)	89,000
Total vessels	10
Total trips	374
Total net tonnage (374 trips)	93,307

Draft of heaviest vessel—light, 3 feet; loaded, 8 feet.
No new lines of transportation were established during the year.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
Lumber	3,582	$20,520	.....	.....
Rice	2,273	71,271	5,365	$87,012
Cotton	834	96,660	508	76.897
Cotton seed	1,338	13,380	586	5,860
Wood	1,239	1,768	1,260	1,920
Cattle	192	8,290	65	6,935
Sugar	1,421	146,325	1,696	124,732
Merchandise	2,058	69,944	1,012	40,480
Molasses	56	1,014	330	1,300
Coal	.....	.....	2,200	10 000
Total	12,993	429,172	13,022	355,136

Comparative statement of receipts and shipments for four years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1893	35,671	$1,227,365	1895	12,993	$429,172
1894	43,822	923,777	1896	13,022	355,136

R 9.

IMPROVEMENT OF MERMENTAU RIVER AND TRIBUTARIES, LOUISIANA.

In 1891 a survey of this river was made, including its tributaries in its course through Lake Arthur and Grand Lake to the Gulf of Mexico, Louisiana.

A project was adopted in 1892 providing for the removal of snags, logs, etc., in the upper river and a mud flat in the lower, at an estimated cost of $23,615.25, and $7,500 was appropriated by Congress for the improvement on July 13, 1892.

Proposals for this work were opened October 6, 1892, and contract was awarded to Harvey & Erlinger, of Harveys Canal, Louisiana, for furnishing a suitable steamboat for snagging purposes, the plant consisting of a stern-wheel steamboat with a crew of 15 men, and having a steam winch, steam capstan, and 2 derricks for removing obstructions, an electric battery for blasting stumps, and all other necessary appliances for this work.

Work was commenced December 8, 1892, and carried on from the lower end of Lake Arthur up the Mermentau River, a distance of 38 miles of channel being improved by the removal of 556 obstructions. The contract was completed March 7, 1893.

An appropriation of $5,000 was made August 17, 1894, for continuing the improvement, and under this appropriation a project was submitted January 17, 1895, the present object being to deepen the water at the Gulf entrance to the river and increase the depths of channel through Mud Lake, but it was not deemed prudent to undertake this work with the funds available, the amount being too small to accomplish anything of a substantial character.

On June 3, 1896, Congress appropriated $5,000 for the continuation of this improvement, and with the aid of these additional funds a project will be formulated and the work of deepening the Gulf entrance to the river will be commenced.

No work under this improvement was done during the fiscal year ending June 30, 1896. The improvements made up to this date are in fairly good condition.

There has been expended on this improvement to June 30, 1896, the sum of $7,121.42.

Abstract of appropriations for improving Mermentau River and tributaries, Louisiana.

By act of Congress—	
Approved July 13, 1892	$7,500
Passed August 17, 1894	5,000
Passed June 3, 1896	5,000
Total	17,500

Money statement.

July 1, 1895, balance unexpended	$5,384.56
Amount appropriated by act of June 3, 1896	5,000.00
	10,384.56
June 30, 1896, amount expended during fiscal year	5.98
July 1, 1896, balance unexpended	10,378.58
Amount (estimated) required for completion of existing project	6,115.25
Amount that can be profitably expended in fiscal year ending June 30, 1898	6,115.25

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	10
Trips	324
Net registered tonnage (324 trips)	16,673
Barges	5
Trips	64
Net tonnage (64 trips)	1,152
Total vessels	15
Total trips	388
Total net tonnage (388 trips)	17,825

Draft of heaviest vessel—light, 3 feet; loaded, 5.7 feet.

No new lines of transportation were established during the year.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
Rice	6,637	$208,107	7,745	$113,365
Lumber	5,123	17,496	3,360	9,940
Wood	2,047	2,945	3,194	3,992
Merchandise	2,148	71,615	2,160	79,480
Total	15,955	300,163	16,459	206,777

Comparative statement of receipts and shipments for four years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1893	16,250	$324,900	1895	15,955	$300,163
1894	5,437	188,950	1896	16,459	206,777

R 10.

IMPROVEMENT OF MOUTH AND PASSES OF CALCASIEU RIVER, LOUISIANA.

Cuts were made through the bars in Calcasieu Lake above Calcasieu Pass in 1874, 1882, and 1883, the dredged channel being 8 feet deep and 70 feet wide and having a length of 7,500 feet. This work was done under contract.

In 1885 the channel needed redredging, having shoaled to a depth of 3½ feet, but through an unfortunate wording of the appropriation the funds could not be applied to this particular work. This trouble was remedied in 1886 and funds appropriated for Calcasieu River became available for both the pass and river.

Contracts were entered into in 1886 for the building of two revetment walls composed of piles and planks, one on each side of the proposed cut, to be about 130 feet apart, each to be a mile or more in length, and to dredge a channel between these, throwing the excavated material outside these walls.

The same contract also provided for the excavation of a channel through the bar at the mouth of Calcasieu River at the northern end of the lake 100 feet wide and 6 feet deep.

Work on the revetment was commenced in the winter of 1886, but the contractor and several of his men died from sickness contracted through exposure to the weather on this work.

In the spring of 1887 work was resumed by the administrator of the contractor's estate and the revetment nearly completed.

At the date of the annual report for 1887 a dredge was expected to begin work within a few weeks, and actually arrived there about the middle of August, but was not ready for work until the last of November on account of necessary repairs and the delay in making them.

About the middle of September, when it was thought the dredge would be ready for operations in a few days at the latest, the administrator began driving down the planking of the revetment into the ditch the water had dug under it, but stopped after one day's work. No work was done by him after that, and the contract was annulled January 3, 1888.

An examination of the revetment showed the woodwork to be so badly worm-eaten as to be worthless, and application was made and approved January 12, 1888, modifying the project so as to omit the revetment.

Authority having been procured, the work was commenced with the Government dredge, which had shortly before completed work on Bayou Terrebonne, March 19, 1888, and carried on until August 31, 1888, two deck barges having been hired and used as dumping scows. The material taken out amounted to 77,159 cubic yards.

In 1888 the sum of $10,000 was appropriated for continuing the improvement, but as the former work proved not to be permanent, and the amount was too small to begin operations with, it was held subject to future consideration.

In 1890 an appropriation of $75,000 was made for "improving the mouth and passes of Calcasieu River," according to the plan reported by Maj. W. H. Heuer, Corps of Engineers, in 1886, and confirmed by Capt. W. L. Fisk, Corps of Engineers, in his report of November, 1888.

As the project contemplated the improvement of the mouth of Calcasieu River by the establishment of jetties, etc., to be built in a very much exposed location in the Gulf, the amount of money available was

considered to be entirely too small to commence operations with economically and was accordingly held for future increase.

The sum of $100,000 was appropriated July 13, 1892, and accordingly a contract was entered into for the construction of a jetty on the east side of the channel across the bar at the mouth of the pass, and for 10,000 linear feet of revetment for the northern side of a channel to be dredged through the bar at the head of the pass. No bids being received for the dredging at rates sufficiently low to warrant acceptance, authority was obtained for the use of the Government dredge in making the channel.

The 10,000 linear feet of revetment was completed August 6, 1893. In November it was considerably damaged by storm and the sum of $3,102.80 expended in its repair. A subsequent storm resulted in some damage, but no funds were available with which to further repair the structure.

The dredging work was carried on from July, 1893, to February, 1894, when the dredge was hauled out and thoroughly repaired, and the work continued from August 3, 1894, to November 1, 1894, completing the channel at the foot of Calcasieu Lake.

The material dredged was soft, and flattened out without making a bank, as was expected, and in consequence the revetment did not receive the protection from this source that was expected, and was accordingly nearly swept away by storms. A substantial breakwater could not be built for the allotted amount of money that would withstand the effects of the storms without the protection of the earth covering, and as this proved to be too soft for any use, the wreck was inevitable and the result very disappointing.

The channel secured by the dredge has remained in use without serious refilling and has given considerable relief.

Owing to unfavorable weather, the contractors were delayed in their work on the east jetty, but finally completed it August 11, 1894, the jetty consisting of a foundation mat upon which a riprap structure was placed, reaching 2 feet above mean high water. The jetty was 7,347 feet in length, the following materials having been placed in same: 33,054.23 tons of riprap stone and 22,396.67 square yards of brush mattress.

Under the appropriation of $90,000 made August 17, 1894, the approved project contemplates dredging channels through the bar at the head of Calcasieu Lake, the capping of 7,000 feet of the east jetty, or such part thereof as available funds would permit, with stone, and using the balance unexpended in dredging a channel 12 feet deep from the 12-foot contour inside to the 12-foot contour outside. Channel to be as wide as funds would permit.

Dredging work was carried on at the head of the lake from November 5, 1894, to June 30, 1895, removing 196,509 cubic yards of material, and giving an available channel 50 feet wide and 8 feet deep. This channel is not considered as permanent on account of the material being washed back into it by the action of the current, the channel requiring revetting in order to prevent this.

Contract for capping the east jetty with stone was approved November 30, 1894, work under same being commenced January 28, 1895, and completed August 8, 1895—9,595.64 tons of capping blocks being used, and 6,552 linear feet of jetty being capped.

Contract was approved March 2, 1896, with Mr. John Winches, Velasco, Tex., for extending east jetty by placing approximately 3,400 square yards brush mattress, 5,000 tons riprap hearting stone, and 800 tons granite capping, the amount of contract being $22,510. Preliminary

operations were commenced by the contractor in April, and active operations in May, 1896, and satisfactory progress is now being made.

The conditions of the contract required the work to be completed by June 15, 1896, but owing to unforeseen circumstances the contractor has been delayed, and an extension of time of forty-five days beyond June 15, 1896, was granted for completing the work, the contractor to bear all additional expense incurred by reason of the extension of time.

Work under the contract was commenced May 22, 1896, and has been continued actively since that time, resulting in the completion of the foundation work and a partial completion of the jetty work, the material placed by the contractor consisting of 3,888.90 square yards of brush mattress and 3,460.24 tons of riprap stone. It is expected that the work will be completed at an early date.

It being reported that the channel at the foot of the lake was obstructed by slabs which had floated into it from the revetment, the work of removing them was let and the channel was cleared at a cost of $399, being completed April 11, 1896.

The amount expended on this improvement during the year was $35,258, making a total expended on the improvement up to the end of the last fiscal year of $295,545.86.

Abstract of appropriations for improving mouth and passes of Calcasieu River, Louisiana.

By act of Congress—		By act of Congress—	
Approved June 10, 1872	$15,000	Approved July 13, 1892	$100,000
Approved March 3, 1881	15,000	Passed August 17, 1894	90,000
Passed August 2, 1882	10,000	Passed June 3, 1896	80,000
Approved July 5, 1884	6,500		
Of August 11, 1888	10,000	Total	401,500
Approved September 19, 1890	75,000		

Money statement.

July 1, 1895, balance unexpended		$61,212.14
Amount appropriated by act of June 3, 1896		80,000.00
		141,212.14
June 30, 1896, amount expended during fiscal year		35,258.00
July 1, 1896, balance unexpended		105,954.14
July 1, 1896, outstanding liabilities	$9,164.32	
July 1, 1896, amount covered by uncompleted contracts	7,215.02	
		16,379.34
July 1, 1896, balance available		89,574.80
Amount (estimated) required for completion of existing project		255,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898		255,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		

Abstract of proposals for extension of east jetty, mouth and passes of Calcasieu River, Louisiana, opened by Maj. James B. Quinn, January 23, 1896.

No.	Name and address of bidder.	3,400 square yards brush mattresses, per square yard.	5,000 tons riprap stone, per ton.	800 tons granite capping stone, per ton.	Total.
1	Edward Perry, Denison, Tex	$0.78	$3.50	$4.75	$23,952
2	Duncan S. Cage, Quintana, Tex	1.07	3.08	4.68	22,782
3	Charles Clarke & Co., Galveston, Tex	.70	3.39	4.80	23,070
4	John Winches, Velasco, Tex	1.20	2.95	4.60	*22,510

*Lowest bid.

Recommendation was made that the contract be awarded to Mr. John Winches, Velasco, Tex., he being the lowest bidder.

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	13
Trips	539
Registered tonnage (539 trips)	11,577
Schooners	39
Trips	274
Net registered tonnage (274 trips)	14,542
Barges	11
Trips	243
Net registered tonnage (243 trips)	21,479
Total vessels	63
Total trips	1,056
Total net tonnage (1,056 trips)	47,598

Draft of heaviest vessel—light, 6 feet; loaded, 9 feet.
No new lines of transportation were established.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
Lumber	221,946	$562,081	185,293	$555,356
Shingles	14,000	19,250	0	0
Cotton	629	27,000	484	31,606
Rice	521	16,342	222	7,030
Merchandise	17,298	163,601	16,776	97,550
Total	254,394	788,274	202,775	691,542

Comparative statement of receipts and shipments for four years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1893	207,545	$2,141,750	1895	254,394	$788,274
1894	344,973	1,600,574	1896	202,775	691,542

R 11.

IMPROVEMENT OF HARBOR AT SABINE PASS, TEXAS.

The original depth of water on the bar at Sabine Pass prior to improvement did not exceed 6 feet. Attempts were made in 1878 and 1880 to increase the depth to 12 or 16 feet by dredging, but the channels thus dredged being unprotected soon filled up. In 1882 a project was approved for improving this entrance by means of jetties and dredging, the estimated cost being $3,177,606.50.

Since the approval of the project $1,798,750 has been appropriated, the expenditures aggregating $1,716,091.96 to June 30, 1894, of which $1,596,091.96 was expended under the present approved project.

At first the jetties were built of layers of brush and rock ballast, but it was found that the brush which was placed in the jetties above the bottom course almost entirely disappeared. At present a large brush mattress is sunk for a foundation and the rock jetty is built upon this until the crest is about 2 feet above mean high water.

There has been an apparent settlement of the jetties since last survey of about 0.5 of a foot; there having been no settlement in the rock section or the concrete station, the settlement noted doubtless is due to a compression of the brush mats. Some expenditure will be necessary

in the preservation of the jetties during their construction as well as after completion, as there has been some loss in the height, caused by the action of the waves.

An appropriation of $275,000 for continuing the improvement of Sabine Pass was made August 17, 1894, and by a subsequent act a sum not exceeding $4,000 was set aside from this amount for dredging and deepening the channel of the Sabine River across the bar at the mouth of the river in Sabine Lake. The expenditure of this sum is detailed in the report for improving Sabine Pass, as the allotment is made from that appropriation.

Under this appropriation the approved project provided for the extension of east jetty, dredging between jetties, and dredging across the bar at the mouth of Sabine River, the latter work to be done with the Government dredge and hired labor, the work to be commenced after the completion of the channel at the head of Calcasieu Lake.

CHANNEL BETWEEN JETTIES.

Dredging on this channel was carried on from July 1, 1893, to February 23, 1894, the contract being completed by the removal of 198,401.26 cubic yards of material.

Contract was entered into under the appropriation of August 17, 1894, covering $115,000 for dredging, and the contractor commenced operations under his contract March 27, 1895, the contract requiring that the work should be completed May 31, 1896, but owing to difficulties experienced by the contractor, unforeseen in the making of the contract, the time was extended forty days.

The channel at present has a depth of 24 feet and an average width of 100 feet, the total amount of material removed under the contract amounting to 1,276,631.74 cubic yards.

Slight fears are entertained relative to the maintenance of this depth and the efficacy of the dredged channel.

JETTIES.

The completion of the contract, June 15, 1894, added 39,150.29 gross tons of riprap stone and 23,333.31 square yards of brush mattress to the west jetty, the jetty being 14,875 feet long, 6,609 feet raised to 2 feet above mean high water, the outer 300 feet being foundation work only.

Contract for the extension of east jetty was approved January 15, 1895, and work was commenced under this contract March 10, 1895, and is still being carried on, the time for the completion of the contract having been extended one hundred and fifty days from March 31, 1896, giving the contractor until the last of August in which to complete his contract.

The completion of this contract will afford great protection to the dredged channel, but not complete protection; the jetty will have to be extended some distance farther out in order to effect this.

On June 30, 1896, the jetty had a total length of 19,500 feet, of which 17,100 has been completed and 2,400 is under course of construction. There has been no change in the west jetty since the last annual report, no work having been done on it during the fiscal year just ended.

Work on the dredged channel was carried on by the contractor during the year, resulting in the widening of the channel to 100 feet and deepening to 25 feet, the channel having been completed June 19, 1896.

The channel has maintained its depth as far as the jetties extend, but has shoaled slightly beyond the ends.

The commerce of the pass at this time is almost altogether in the shipment of pine lumber to coastwise and foreign ports, to wit, 45,122 tons valued at $172,681. One of the compensatory results of the work has been the reclaiming from tidal overflow of about 85,000 acres of pasture lands between the east shore of Sabine Lake and Grand Lake. Two new railroads from the great Northwest are being pushed to completion with the design of making the pass a great grain shipping and importing port. One of these roads has already located its terminal point at Port Arthur on Sabine Lake, a part of its plan being to dredge a channel of sufficient depth to permit vessels to come from the pass and land at its wharves.

The amount expended on the work to June 30, 1896, was $2,007,542.02.

Under the allotment of $4,000 from the sundry civil act of March 2, 1895, for the dredging of the bar at the mouth of Sabine River, Texas, operations were commenced August 1, 1895, and carried on actively to December, 1895, with the Government dredge, resulting in the establishment of a satisfactory channel 50 feet wide and 8 feet deep from deep water in Sabine River to deep water in the lake.

There were removed by the dredge 73,334 cubic yards of material and 22 logs, giving great relief to navigation.

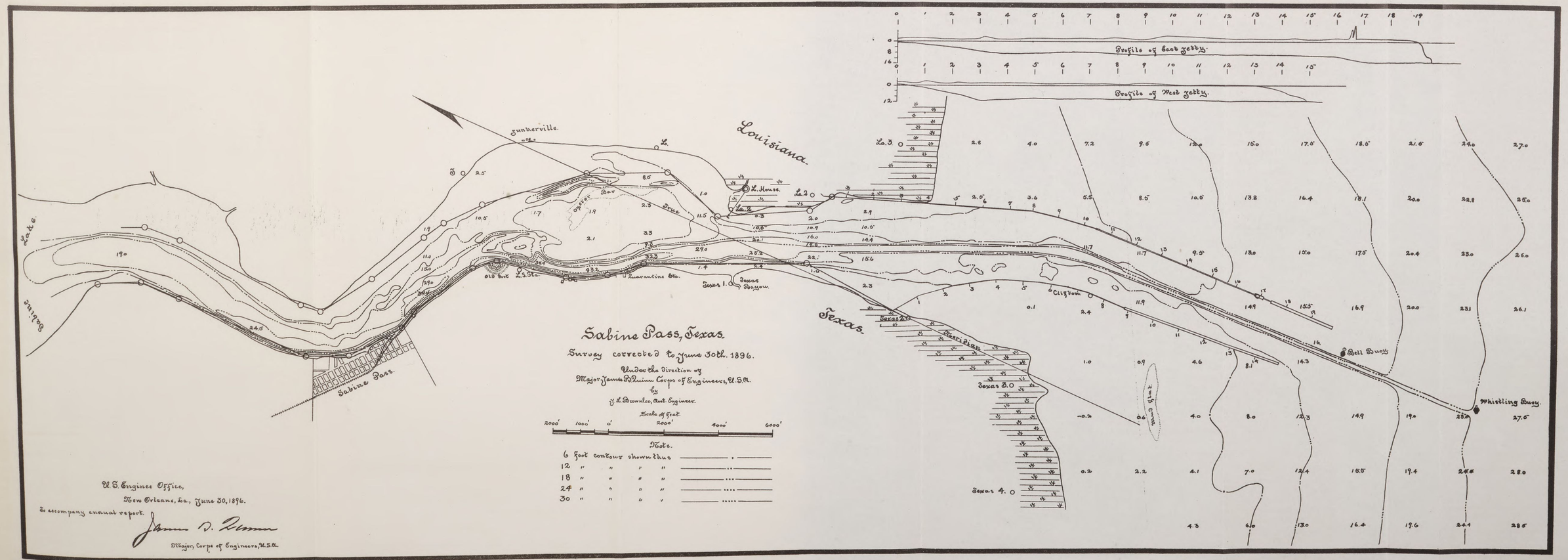
Abstract of appropriations for improving harbor at Sabine Pass, Texas.

From act approved August 30, 1852 (survey)	$5,000
Allotted from act of Congress approved June 10, 1873 (for survey)	2,000
By act of Congress—	
Approved March 14, 1875	20,000
Approved August 14, 1876	38,000
Approved June 18, 1878 (allotted)	30,000
Approved March 3, 1879	25,000
Approved June 14, 1880	50,000
Approved March 3, 1881	150,000
Passed August 2, 1882	150,000
Approved July 5, 1884	200,000
Approved August 5, 1886	198,750
Of August 11, 1888	250,000
Approved September 19, 1890	300,000
Approved July 13, 1892	275,000
Passed August 17, 1894	* 271,000
Passed June 3, 1896	75,000
Total	2,114,750

Money statement.

July 1, 1895, balance unexpended		$264,705.48
Amount appropriated by act of June 3, 1896		75,000.00
		339,705.48
June 30, 1896, amount expended during fiscal year		228,497.50
July 1, 1896, balance unexpended		111,207.98
July 1, 1896, outstanding liabilities	$11,765.23	
July 1, 1896, amount covered by uncompleted contracts	24,097.68	
		35,862.91
July 1, 1896, balance available		75,345.07
Amount (estimated) required for completion of existing project		1,378,856.50
Amount that can be profitably expended in fiscal year ending June 30, 1898		1,000,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		

* The total amount of this appropriation was originally $275,000, but of this sum $4,000 was allotted by sundry civil act of March 2, 1895, for the dredging of a bar across the mouth of Sabine River, Texas, and was expended under that improvemnte.



ANDREW B. GRAHAM PHOTO-LITHO WASHINGTON D.C.

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COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Vessels	54
Trips	205
Net registered tonnage (205 trips)	47,259

Draft of heaviest vessel—light, 10 feet; loaded, 17.6 feet.
No new lines of transportation were established.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
SHIPMENTS.				
Lumber	30,383	$164,081	45,221	$172,681
Merchandise	1,415	20,535	240	11,975
Total	32,799	184,616	45,461	184,656
RECEIPTS.				
Rock	5,115	14,355	1,009	1,886
Coal	1,275	5,427	580	2,610
Merchandise	9,052	48,425	1,836	9,890
Grand total	47,691	252,823	48,886	199,042

Comparative statement of receipts and shipments for five years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1892	38,028	$225,963	1895	47,691	$252,823
1893	15,050	180,950	1896	48,886	199,042
1894	46,966	280,189			

R 12.

IMPROVEMENT OF SABINE RIVER, TEXAS.

The mouth of this river was surveyed in 1871, at which time there was a depth of 3½ feet of water over the bar. In 1872–73 the survey was extended up the river to Belgora, Tex., but the information obtained did not warrant the expenditure of money in the improvement of the river above Hamilton, Tex., a distance of 247 miles from the mouth, there being a depth of 3 feet of water about three months of each year, the estimated cost of the improvement being placed at $18,000, and providing for the removal of obstructions such as logs, snags, fallen trees, etc.

An appropriation of $10,000 was made in 1878, with which a channel 6 feet deep and 70 to 100 feet wide was dredged through the bar at the mouth.

A further appropriation of $6,000 was made in 1879, providing for a resurvey of the river from the mouth to East Hamilton, the result of the survey being a determination to spend the funds in improving the river above Orange, and accordingly cuts were made from the main river into the Narrows and at Dead Bend, and a large number of sunken logs were removed from the Narrows, enabling vessels of 5 feet draft to get 30 miles above Orange.

Congress appropriated $5,000 in 1880 and $7,000 more in 1881, and the bar at the mouth having shoaled was redredged to a depth of 6 feet and the channel made 100 feet wide, extending a little over a mile, the work being completed in 1882.

A further appropriation of $4,000 was made in 1882, but as the river was considered to be in a sufficiently good condition for the commerce it carried the money was held for future use.

An examination was made in 1889, which developed the fact that the channel was obstructed, especially in the Narrows, and as $4,000 was available a project was approved providing for a removal of the snags, etc., and closure of the two branches of Old River, throwing the water into the Narrows. Contract under this project was entered into September 20, 1889, the work to be completed December 1, 1889, but owing to the rising of the river after a part of the work had been done the time for the completion of the work was extended until October 30, 1890, but the work was not completed until December, 1890.

A project was approved in 1892 looking to the improvement of the river between Sabine Lake and Sudduths Bluff, by the removal of obstructions, at an estimated cost of $10,000. Under this project an appropriation of $5,000 was made July 13, 1892, and the work was let under contract.

Work was carried on from July 1 to September 26, 1893, improving 17½ miles of channel by the removal of 1,325 obstructions.

The sum of $5,000 was appropriated August 17, 1894, for completing the project of 1892, and with this sum it was proposed to remove the obstructions which had re-formed in the cleared channel, and continue the improvement up to Sudduths Bluff. Contract for this work was approved February 26, 1895, and work under the contract continued from July 1, 1895, to October 31, 1895, the improvement extending from Morgans Bluff to Cypress Bayou, a distance of 20 miles, the obstructions removed consisting of 1,019 logs, 130 snags, and 877 overhanging trees. The river is now in a fairly good navigable condition up to Sudduths Bluff, but the improvement is not considered permanent, as obstructions continue to re-form, which it is estimated will require an expenditure of about $2,000 annually to remove.

The sum of $4,000 was allotted by act of March 2, 1895, from the appropriation for improving Sabine Pass, for dredging across the bar at the mouth of the river, and this work was done by the Government dredge, being completed in December, 1895, and resulting in the completion of a channel 50 feet wide and 8 feet deep from deep water in Sabine River to deep water in the lake.

The shipments of lumber from the Sabine River, its main product, of a value not less than $649,380, was attended this year with drawbacks in the matter of extra handling and expense, as the Sabine River flows into Sabine Lake, and all of its river commerce must pass the lake and over its shoals to be loaded on the vessels at Sabine Pass. Notwithstanding this, the shipping interests of Sabine River have been stimulated by the establishment of a deep harbor at Sabine Pass, one mill having furnished information of a contract now in hand of 12,000,000 feet of lumber for Chicago via vessels to New York and the Great Lakes, a contract made possible only because of the improvement of the pass. The value of the commerce from the river was increased about $240,000 during the last year.

There was expended on this work during the fiscal year just ended the sum of $4,945.18, making a total of $44,560.62 expended on the work of improvement to June 30, 1896.

Abstract of appropriations for improving Sabine River, Texas.

Allotted from act approved June 10, 1872	$2,700
By act of Congress—	
Approved June 18, 1878	10,000
Approved March 3, 1879	6,000
Approved June 14, 1880	5,000
Approved March 3, 1881	7,000
Passed August 2, 1882	4,000
Approved July 13, 1892	5,000
Passed August 17, 1894	5,000
Passed June 3, 1896	2,000
Total	46,700
Amount allotted from appropriation of $275,000 for improving Sabine Pass, Texas, by sundry civil act, March 2, 1895, and expended under this appropriation	4,000
Total	50,700

The above amount was allotted for dredging bar across the mouth of Sabine River from the appropriation dated August 17, 1894, for improving Sabine Pass, Texas, and the work was done by the Government dredge and hired labor.

Money statement.

July 1, 1895, balance unexpended	$5,084.56
Amount appropriated by act of June 3, 1896	2,000.00
	7,084.56
June 30, 1896, amount expended during fiscal year	4,945.18
July 1, 1896, balance unexpended	2,139.38
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	2,000.00

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	7
Trips	174
Net registered tonnage (174 trips)	9,526
Schooners	17
Trips	69
Net registered tonnage (69 trips)	1,664
Barges	7
Trips	99
Net registered tonnage (99 trips)	13,000
Total vessels	31
Total trips	342
Total net tonnage (342 trips)	24,190

Draft of heaviest vessel—light, 30 inches; loaded, 5 feet 6 inches.
No new lines of transportation were established during the year.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
Lumber	179,628	$646,144	265,591	$649,380
Cotton	249	28,500	1,036	160,000
Staves	.....	.....	550	2,000
Wool	.....	.....	30	6,000
Merchandise	2,861	61,400	4,050	162,000
Total	182,738	736,044	271,257	979,380

Comparative statement of receipts and shipments for four years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1893	146,363	$1,591,280	1895	182,738	$736,044
1894	245,657	1,518,630	1896	271,257	979,380

R 13.

IMPROVEMENT OF NECHES RIVER, TEXAS.

The river was surveyed in 1872–73, and afterwards resurveyed from Bevilport to its mouth, the project for the improvement of the river contemplating the removal of obstructions from the channel between Bevilport and Yellow Bluff and the dredging of the bar at the mouth.

A channel was dredged through the bar at the mouth of the river in 1880, 5 feet deep and from 30 to 60 feet wide, the obstructions between Yellow Bluff and Bevilport being removed in 1882.

The original estimate of the cost of the improvement was $26,318.05 for the work at the mouth of the river, and $15,000 for the work on the river itself, removing obstructions, etc., making a total of $41,318.05.

As the bar at the mouth of the river shoaled up until at extreme low water there was but a depth of 3 feet over it, and as the money was available with which to do the work, it was deemed advisable to reopen the channel, this being the shoalest obstruction between the Gulf and Beaumont, Tex. It was decided to do the work with the Government dredge, and accordingly it was put in good repair and sent over from Calcasieu Pass, where it had been at work, December, 1888, the operations being continued until May, 1889, completing a 5-foot channel in line of the old one, traces of which still remained.

In 1895 a project was submitted and approved March 29, 1895, providing for a channel 6 feet deep and 100 feet wide from deep water in Neches River to deep water in Sabine Lake, there being a balance of $4,157.84 available for the work.

Operations were commenced with the Government dredge under this project in January, 1896, and carried on until May 30, 1896, resulting in the removal of 74,885 cubic yards of material and 15 logs, leaving a channel 6 feet deep and 50 feet wide.

This improvement was necessitated by the demands of an increased commerce, attracted by the deep-water improvement at Sabine Pass, Tex., but it is not deemed permanent, as the channel is certain to shoal up again. However, it is deemed that it will serve every purpose for which it is used for some time.

By an examination of the commercial statistics of this river, it will be noted that the commerce, notably in cotton and cattle, on this river has deteriorated in tonnage and values, because, as asserted by the steamboat men, the losses in time and extra running expenses caused by the delays in getting by the great rafts of mill timber, which not infrequently are allowed to obstruct navigation, and the dangers from and damage done by sunken logs and butts has made its navigation so unprofitable as to cause its abandonment, except as to the lower part, a short distance below Beaumont, to its mouth.

The work of dredging the channel through the bar at the mouth of Neches River was completed May 31, 1896, thus could have had no effect on the commerce of the fiscal year just ended. The value of the

commerce involved, according to commercial statistics contained in statement below, is $324,075. The cost of improvement to date is $32,872.70, there having been expended during the fiscal year ending June 30, 1896, $4,030.54.

Abstract of appropriations for improving Neches River, Texas.

By act of Congress—		By act of Congress—	
Approved June 18, 1878	$8,000	Passed August 2, 1882	$5,000
Approved March 3, 1879	5,000	Approved July 5, 1884	7,000
Approved June 14, 1880	3,000		
Approved March 3, 1881	5,000	Total	33,000

Money statement.

July 1, 1895, balance unexpended	$4,157.84
June 30, 1896, amount expended during fiscal year	4,030.50
July 1, 1896, balance unexpended	127.30
July 1, 1896, outstanding liabilities	10.00
July 1, 1896, balance available	117.30

COMMERCIAL STATISTICS.

[From June 1, 1895, to May 31, 1896.]

Steamers	5
Trips	35
Net registered tonnage (35 trips)	586
Barges	6
Trips	35
Net registered tonnage (35 trips)	5,680
Total vessels	11
Total trips	70
Total net tonnage (70 trips)	6,266

Draft of heaviest vessel—light, 14 inches; loaded, 4 feet.
No new lines of transportation were established.

Receipts and shipments for two years.

Articles.	Year ending May 31—			
	1895.		1896.	
	Tons.	Value.	Tons.	Value.
Lumber	143,122	$405,090	136,651	$303,525
Hides	4	402	.....	.....
Cattle	110	3,000	.....	.....
Merchandise	515	52,528	450	17,850
Rice	2,867	83,700	167	2,700
Total	146,618	544,720	137,268	324,075

Comparative statement of receipts and shipments for four years.

Year ending May 31—	Tons.	Value.	Year ending May 31—	Tons.	Value.
1893	77,533	$600,410	1895	146,618	$544,720
1894	165,528	593,754	1896	137,268	324,075

R 14.

REMOVING SUNKEN VESSELS OR CRAFT OBSTRUCTING OR ENDANGERING NAVIGATION.

Wreck of the steamer Queen of the West in Grand Lake, Louisiana.—This wreck formed an obstruction to the navigation of Grand Lake, Louisiana, and its removal was authorized by the Secretary of War June 4, 1895, an allotment of $1,200 being made therefor, the amount being increased to $1,400 August 22, 1895, the allotment being made from the permanent appropriation for removing sunken vessels or craft obstructing or endangering navigation.

Specifications of the work were printed and advertisements soliciting proposals for the work were published, and under date of August 29, 1895, contract was entered into with Mr. Henry Camors, of New Orleans, La., for the removal of the wreck for the sum of $1,187, the contract being approved September 7, 1895.

Work was commenced under this contract on October 2, 1895, and completed October 28, 1895, resulting in the complete removal of the wreck and the restoration of navigation free of obstructions.

Wreck of the steamer Exchange in Bayou Vermilion, Louisiana.—This wreck lay in the channel of Bayou Vermilion, about 2 miles south of Abbeville, La., and formed a serious obstruction to the free navigation of the bayou. Its removal was authorized by the Secretary of War on July 5, 1895, and the sum of $2,000 was allotted for the work from the permanent indefinite appropriation for removing sunken vessels or craft obstructing or endangering navigation.

Contract was entered into October 7, 1895, with the New Orleans Diving and Wrecking Company, of New Orleans, La., and approved October 18, 1895, for the sum of $875.

Operations were commenced October 29, 1895, by the contractors and completed November 11, 1895, resulting in the complete removal of the wreck and the restoration of unobstructed navigation of the bayou.

Abstract of proposals for removing wreck of the steamboat Queen of the West, in Grand Lake, Louisiana, received in response to advertisement dated July 16, 1895, opened August 16, 1895, by Maj. James B. Quinn, Corps of Engineers.

No.	Name and address of bidder.	Amount of bid.
1	New Orleans Wrecking Co., New Orleans, La	$1,800
2	Geo. E. Surgi, New Orleans, La	1,500
3	Henry Camors, New Orleans, La.*	1,187

* Lowest bidder.

Contract was entered into with Mr. Henry Camors, New Orleans, La., he being the lowest bidder, August 29, 1895, and approved September 7, 1895.

Abstract of proposals for removing wreck of steamboat Exchange in Bayou Vermilion, Louisiana, opened at New Orleans, La., September 12, 1895, by Maj. James B. Quinn, Corps of Engineers.

No.	Name and address of bidder.	Amount of bid.
1	New Orleans Wrecking Co., New Orleans, La.*	$875
2	W. M. Wenzel, Algiers, La	1,212
3	Eli Wise, Abbeville, La	1,420

* Lowest bidder.

The bid of the New Orleans Wrecking Company was accepted, and contract entered into October 7, 1895.

R 15.

ESTABLISHMENT OF HARBOR LINES IN HARBOR AT SABINE PASS, TEXAS.

COMMITTEE ON RIVERS AND HARBORS,
HOUSE OF REPRESENTATIVES, UNITED STATES,
Washington, D. C., January 29, 1896.

SIR: Under the present contract for the improvement of the harbor of Sabine Pass, Tex., a minimum depth of channel, at mean low tide, of 25 feet is to be secured. The importance of this harbor, and the fact that port facilities therefor on a comprehensive scale are soon to be provided, make it necessary that the harbor line should be run. Complying, therefore, with the request of certain of the citizens of Sabine Pass, and other persons interested therein, I ask that action may be taken thereon, in pursuance of the provision of section 12 of the river and harbor act of 1890, which will insure the running of the harbor line as soon as practicable.

Respectfully,

W. B. HOOKER,
Chairman.

Hon. DANIEL S. LAMONT,
Secretary of War.

[Second indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
January 31, 1896.

Respectfully referred to Maj. James B. Quinn, Corps of Engineers, for prompt report.

If in Major Quinn's opinion the establishment of harbor lines at this locality is essential to the preservation and protection of the harbor, he will please prepare and submit to this office for action a map showing the harbor lines recommended for adoption. He is requested to consult personally the parties interested in navigation and in the dock property, and prepare a project showing a system of harbor lines which will, if possible, be satisfactory to the interests of navigation, as well as to the owners of the land along the harbor front.

By command of Brig. Gen. Craighill:

A. MACKENZIE,
Lieut. Col., Corps of Engineers.

[Third indorsement.]

OFFICE UNITED STATES ENGINEER,
New Orleans, La., March 11, 1896.

Respectfully returned to the Chief of Engineers, U. S. Army, with a tracing* of the harbor at Sabine Pass, Tex., inclosed, upon which is shown the location of dock lines which were determined upon after consultation with the parties interested.

The description of the lines is to be found in the tables of the tracing.

JAMES B. QUINN,
Major, Corps of Engineers.

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* Not printed.

[Fourth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
March 16, 1896.

Respectfully returned to the Secretary of War.

This is a request for establishment of harbor lines at Sabine Pass, Tex., and the subject has been considered by Maj. James B. Quinn, Corps of Engineers, who recommends certain lines shown and described on the tracing herewith submitted.

I concur in the views of Major Quinn and recommend that the Secretary place his approval both on this paper and on the inclosed tracing which has been prepared for his signature.

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

[Fifth indorsement.]

WAR DEPARTMENT,
March 19, 1896.

Approved as recommended by the Chief of Engineers.

DANIEL S. LAMONT,
Secretary of War.

APPENDIX S.

IMPROVEMENT OF CERTAIN RIVERS AND HARBORS IN TEXAS.

REPORT OF MAJ. A. M. MILLER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Galveston Harbor, Texas.
2. Ship channel in Galveston Bay, Texas.
3. Channel in West Galveston Bay, Texas.
4. Trinity River, Texas.
5. Buffalo Bayou, Texas.

SURVEYS.

6. Trinity River, Texas, from Magnolia to Dallas.
7. Galveston Island, Texas.

HARBOR LINES.

8. Galveston Harbor, Texas.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., July 15, 1896.

GENERAL: I have the honor to forward herewith annual reports for the works of river and harbor improvements in my charge for the fiscal year ending June 30, 1896.

Very respectfully, your obedient servant,

A. M. MILLER,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

S 1.

IMPROVEMENT OF GALVESTON HARBOR, TEXAS.

Galveston Harbor embraces an anchorage area of over 1,960 acres, of which 460 acres have a depth of more than 30 feet and over 1,500 acres have a depth of more than 20 feet. It is landlocked by Galveston Island, Pelican Island, the shoals in the bay, and Bolivar Peninsula, thereby affording vessels excellent shelter from storms. Waterways connect it with Houston and with Brazos River.

The entrance to the harbor, between Galveston Island and Bolivar Peninsula, was originally obstructed by a sand bar on which the depth

of water was but 12 feet; a second bar, having a depth on it of 13 feet, existed at the entrance to Galveston Channel, along which the city's water front extends with its system of wharves.

The project for improving this harbor was adopted in 1874, modified in 1880 and again in 1886, the object being to deepen the channel at the entrance so as to permit ocean vessels of the deepest draft to enter the harbor.

The projects of 1874 and 1880 contemplated the construction of two jetties extending into the Gulf of Mexico, so as to concentrate the ebb flow of the tide upon the outer bar and thus gradually wear it away, also to cause a deepening of the bar at the entrance of Galveston Channel, these jetties to have their origins respectively at Fort Point on Galveston Island and Boliver Point on Bolivar Peninsula.

More or less work was done under these projects. Between 1870 and 1880 about $605,000 was spent on gabionades, dredging, and pile-driving, which resulted in the removal of the inner bar.

Between 1880 and 1884 about $970,000, including $100,000 appropriated by the city of Galveston, was spent on brush and rock construction of the south jetty from Fort Point to the crest of the outer bar. This work resulted in an increase in depth of 1 foot.

In 1886, the matter of the improvement was referred to a board of engineers who formulated the existing project. This also consists in the construction of two jetties extending into the Gulf, one, the south jetty, starting from the east end of Galveston Island and following the line of the jetty previously constructed, and the other, the north jetty, starting from Bolivar Point. In 1888 it was decided to connect the inner end of the south jetty with the relatively high ground on which the city of Galveston was built by a stone dike known as the shore branch.

The jetties were to be built of riprap covered by granite blocks and were to be carried to an elevation of 5 feet above mean low tide, and to extend, if necessary, to the 30-foot contour in the Gulf, their sea ends to be 7,000 feet apart. The action of the jetties was to be supplemented if necessary by dredging.

The general plan of the work is shown on the accompanying map.

At the close of the fiscal year ending June 30, 1895, the progress made in the work was as follows:

The south jetty had been completed for a distance of 32,000 feet and an apron 829 feet long had been constructed at its sea end to prevent scour.

The north jetty had been completed for a distance of 18,500 feet and partially completed for a further distance of 4,000 feet.

Dredging had also been carried on for a period of about two and a half months, 68,071 cubic yards of material having been removed during that time.

The effect of the work was plainly shown, the inner bar having entirely disappeared and the depth on the outer bar having increased from 12 to $17\frac{3}{4}$ feet, a gain of $5\frac{3}{4}$ feet.

During the present fiscal year the construction of both jetties was continued under the continuous contract entered into with O'Connor, Laing & Smoot, of Dallas, Tex., on May 12, 1891, and approved June 2, 1891.

The progress made on each jetty during the year was as follows:

SOUTH JETTY.

When work was suspended on this jetty in 1893 it had been completed to station 320, a distance of 32,000 feet. Its construction was

resumed with this fiscal year, at the end of which it had been completed a total distance of 33,100 feet, an advance of 1,100 feet. It is partially completed for a further distance of 1,920 feet, the sea end being within 680 feet of its probable outer extremity.

NORTH JETTY.

The advance of the completed work on this jetty amounted to 4,800 feet for the year, the length being then 23,300 feet; in addition it was partially completed for a further distance of 1,810 feet, the sea end being 790 feet from its probable outer extremity.

The total length of jetties constructed since work began in 1887 is as follows:

	Feet.
South jetty, completed	33,100
South jetty, partially completed	1,920
North jetty, completed	23,300
North jetty, partially completed	1,810
Total to June 30, 1896	60,130

A detailed account of the work is shown in the reports of Lieut. W. V. Judson, Corps of Engineers, and Mr. E. M. Hartrick, assistant engineer, which are forwarded herewith and to which attention is invited.

DREDGING.

At the beginning of the present fiscal year dredging was being carried on under a contract entered into with O'Connor & Smoot, of Galveston, Tex., on May 4, 1895, and approved May 14, 1895, work to commence May 4, 1895, and to be completed August 4, 1895. This contract was completed on July 31, 1895, 32,698 cubic yards of material having been removed since July 1, 1895, at a cost of 35 cents per cubic yard.

As the U. S. dredge *Gen. C. B. Comstock* had not been delivered at the expiration of this contract, it became necessary to enter into a second contract with them on July 23, 1895, approved August 2, 1895, to continue the dredging at the same price, work to commence on or before August 5, 1895, and to be completed by September 15, 1895.

Under this contract 112,827 cubic yards of material was removed at a cost of 35 cents per cubic yard.

The total amount of material dredged under both contracts of O'Connor & Smoot was 213,596 cubic yards.

DREDGE GEN. C. B. COMSTOCK.

The construction of the dredge *Gen. C. B. Comstock*, which was commenced during the previous fiscal year under a contract entered into with the Bucyrus Steam Shovel and Dredge Company, of South Milwaukee, Wis., on October 6, 1894, and approved October 17, 1894, work to commence October 15, 1894, and to be completed August 1, 1895, was finished and the vessel delivered at Galveston, Tex., on August 31, 1895.

Under the terms of the contract the dredge was to stand a ten days' trial before final acceptance by the Government. This trial was completed September 26, 1895, and the vessel was accepted. Since that time the dredge has been continuously employed in dredging when the state of weather would permit, except such time as was required for making repairs.

The total amount of material dredged was 419,748 cubic yards, of which 201,243 cubic yards was sand taken from the outer bar and 218,505 cubic yards mud and clay from inside the bar. The average cost per cubic yard was 7.4 cents.

A description of the dredge and details of the dredging are given in the report of Lieut. W. V. Judson, Corps of Engineers, which is forwarded herewith and to which attention is invited.

COAL WHARF.

For the purpose of securing a more economical supply of coal the construction of a coal wharf was authorized on the Government reservation at Fort Point. A contract was entered into on September 25, 1895, with J. W. Byrnes, of Galveston, Tex., for constructing the wharf, at a cost of $6,000, work to commence September 20, 1895, and to be completed by November 15, 1895.

Up to the close of the present fiscal year a saving on coal has been effected equal to about five-sixths of the cost of the wharf.

TIDAL OBSERVATIONS.

These observations were continued throughout the year, three automatic tide gauges having been in operation, and were in charge of Lieut. W. V. Judson, Corps of Engineers, whose report is forwarded herewith.

STORMS.

The most severe storm since July 5, 1891, visited this locality on August 28 to 30, 1895. The maximum velocity attained by the wind was 33 miles per hour from the southeast, which raised the water to a point 3.8 feet above mean low tide on the bar; the duration of the storm was about thirty-six hours.

It caused some damage to the jetties, principally at the sea ends where the trestle was unprotected, and also effected a general leveling down of sandstone where there was no granite protection.

While the storm had an injurious effect on the uncompleted portions of the jetties, it caused a marked improvement in the channel across the bar, so that the money damage was probably more than compensated for.

SURVEYS.

For the purpose of watching the progress of the work monthly surveys were made of the bar and channel, blue prints of which were forwarded with monthly reports.

These surveys showed the following least depths on the bar at mean low tide:

	Feet.		Feet.
July, 1895	17¾	January, 1896	21
August, 1895	18½	February, 1896	22
September, 1895	20	March, 1896	22¼
October, 1895	20	May, 1896	22¼
November, 1895	20¾	June, 1896	22
December, 1895	20¾		

For the purpose of determining the amount of scour and fill between and beyond the jetties, a survey was made in January–February, 1896, in order to make a comparison with a survey made in June–July, 1894. This comparison showed that an excavation of 16,600,881 cubic yards and a fill of 7,726,477 cubic yards had taken place.

A report on this survey, giving results in detail, will be found in the report of Lieut. W. V. Judson, Corps of Engineers, forwarded herewith.

The usual annual survey of the harbor and vicinity was made in April–June, 1896, a map of which is forwarded herewith. This map has on it the contours of 1887, 1895, and 1896, thus showing the changes that have occurred during the year; also since work was commenced under the present project.

The practical result of the work can be judged from the increased depth at which vessels have been able to load since the improvement was commenced.

The deepest loaded vessel that crossed the bar previous to the present fiscal year was on May 14, 1895, her draft being 18¼ feet. Since then the following vessels have entered or cleared, the draft in each case being the greatest up to the date given:

November 1, 1895, steamship *Ramazan* cleared, drawing 20 feet.
January 21, 1896, steamship *Eugenia* cleared, drawing 20 feet 7 inches.
February 18, 1896, steamship *Dartmoor* cleared, drawing 21 feet.
February 23, 1896, ship *Khyber* entered, drawing 21 feet 3 inches.
March 21, 1896, steamship *Sicilia* entered, drawing 21 feet 6 inches.
March 26, 1896, steamship *Helen* cleared, drawing 21 feet 4 inches.
April 16, 1896, steamship *City of Gloucestor* cleared, drawing 21 feet 6 inches.
June 5, 1896, steamship *Galitia* cleared, drawing 21 feet 10 inches.

Since the fact that deep water at Galveston has become assured, the eyes of the commercial world have been directed that way. Representatives of most of the leading steamship lines of the world have been here to canvass the situation, and it is probable that before long nearly all of those lines will be sending ships to Galveston.

During the present year the following lines have been added to those using Galveston as a port:

The Harrison Line.
The West India and Pacific Line.
The Hamburg-American Line.

Two other railroads have also come to Galveston, and there is a strong probability of the Southern Pacific Railway making it one of the terminals of its road.

By authority of Department letter of March 31, 1896 (14611) the estimated amount required to complete existing project has been increased by the sum of $250,000.

The reason for this increase is due to the fact that Congress in the acts of August 18, 1894, March 2, 1895, and June 11, 1896, allotted the sum of $250,000 for dredging. This work was not included in the estimated cost of the work ($7,000,000) made by the Board of Engineers in 1886. This estimate only covered jetty construction, the outer extremities of the jetties being located at the 30-foot contour of 1887, which was at station 356 of south jetty and station 259 of north jetty; therefore if the estimated cost be reduced by the amount expended in dredging, the length of the jetties would necessarily be shortened, thus leaving the project uncompleted.

Amount expended under previous projects to June 30, 1895	$1,477,903.00
Amount expended under present project to June 30, 1895	4,112,970.49
Amount expended during fiscal year ending June 30, 1896	1,319,132.93
Total expended to June 30, 1896	6,910,006.42

In addition to this, the sum of $100,000 was expended which was subscribed by the city of Galveston in 1883.

Abstract of appropriations made by Congress for improving harbor at Galveston, Tex.

By act of—		By act of—	
July 11, 1870	$25,000	August 5, 1886	$300,000
March 3, 1871	20,000	August 11, 1888	500,000
June 10, 1872	31,000	September 19, 1890	500,000
June 23, 1874	60,000	March 3, 1891	600,000
March 3, 1875	150,000	August 5, 1892	450,000
August 14, 1876	142,000	March 3, 1893	1,000,000
June 7, 1878	75,000	August 18, 1894	600,000
June 18, 1878	50,000	January 25, 1895	200,000
March 3, 1879	100,000	March 2, 1895	1,160,000
June 14, 1880	175,000	February 26, 1896	300,000
March 3, 1881	250,000	June 11, 1896	840,000
March 4, 1882	100,000		
August 2, 1882	300,000	Total	7,928,000

In addition to the above appropriations by Congress there has been collected from steamship *Maritime* 300

Total 7,928,300

Abstract of appropriations made by Congress for dredging bar at Galveston, Tex.

By act of June 3, 1896 ..... $50,000

Money statements.

IMPROVING HARBOR.

July 1, 1895, balance unexpended		$1,197,029.51
February 25, 1896, amount collected from steamship *Maritime*		300.00
Amount appropriated by general deficiency act approved February 26, 1896		300,000.00
Amount appropriated by sundry civil act approved June 11, 1896		840,000.00
		2,337,329.51
June 30, 1896, amount expended during fiscal year		1,319,132.93
July 1, 1896, balance unexpended		1,018,196.58
July 1, 1896, outstanding liabilities	$172,807.11	
July 1, 1896, amount covered by uncompleted contracts	765,389.47	
		938,196.58
July 1, 1896, balance available		80,000.00
Amount (estimated) required for completion of existing project		800,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898		800,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		

DREDGING BAR.

Amount appropriated by act of June 3, 1896	$50,000.00
July 1, 1896, balance unexpended	50,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	50,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

Abstract of proposals for constructing a coal wharf at Galveston, Tex., received in response to circular dated August 15, 1895, and opened August 29, 1895, at Galveston, Tex., by Maj. A. M. Miller, Corps of Engineers.

No.	Name and address of bidder.	Plan No. 1.	Plan No. 2.
1	O'Connor & Smoot, Galveston, Tex	$7,750.00	$8,350.00
2	McHenry & Ketchum, Galveston, Tex	6,856.50	7,944.30
3	J. W. Byrnes, Galveston, Tex	6,200.00	6,000.00

No. 3 lowest bid; acceptance recommended per plan No. 2.

REPORT OF FIRST LIEUT. WILLIAM V. JUDSON, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., June 30, 1896.

MAJOR: I have the honor to report as follows upon the work assigned me by you during the fiscal year ending June 30, 1896:

TIDAL OBSERVATIONS.

During the year three automatic gauges have been in continuous operation, except as interruptions have occurred on account of storms, etc.

The platting of the records has been kept up to date.

The bar gauge is located outside the jetties, being about 500 feet north of the north jetty and about 3½ miles from the shore line. While its fluctuations are more than formerly affected by winds, which sometimes bank up the water in the angle between the north jetty and the shore line, yet for any considerable period of time its mean fluctuation should be that of the Gulf, unaffected to a great extent by the jetties as constructed.

The mean fluctuations at bar gauge have been compared month by month since the beginning of the north jetty, in July, 1893, with the mean fluctuation at gorge gauge and Government Wharf. These comparisons are shown graphically in fig. 5, pl. 1, where the abscissæ represent time in months and the ordinates the ratios $\frac{\text{B. G.}}{\text{G. G.}}$ and $\frac{\text{B. G.}}{\text{G. W.}}$, respectively.

In figs. 3 and 4, pl. 1, are shown similar graphical illustrations of the increased retardations of high and low water at gorge gauge and Government Wharf as compared with bar gauge. These data do not, of course, determine the extent of diminution of the tidal prism, but they indicate that some effect of this kind has been produced. A calculation of the present tidal prism would involve the establishment of several additional gauges or actual current measurement at the gorge. By the latter method one gauging of an ebb tide has been made. A line was established from jetty to jetty and perpendicular to the south jetty. Eleven stations upon this line were marked with buoys. The tide was read at the end of the south jetty and at Fort Point. From 2.27 a. m. until 2.02 p. m., December 5, observations with a Ritchie-Haskell direction current meter were made at the stations in order from 0 to 10. When 10 was reached the meter was taken back to 0 and the work continued as before. Short observations were taken, the object being to obtain for each station as many observations as possible. The mid-depth velocity was measured, the mean velocity in a vertical plane at the time of each observation being deduced therefrom by the formula $Vm = V\frac{1}{2}\ D \times .958$. In this manner Vm was determined for each station at intervals throughout the ebb. Finally, the mean velocity for each station for the whole ebb was obtained and multiplied by the partial cross-sectional area embracing the station. The summation of these partial prisms gave a total tidal prism of 6,082,477,272 cubic feet. The tide observed was an intermediate declination one. A gauging of a single tide is perhaps without great value. The method employed was not an exact one, but the best that could be devised, it is believed, with a single-current meter. At the time set apart for the work other determinations were prevented by rough seas. The result obtained, however, is given here as a check upon the calculated tidal prisms given on page 1888, Annual Report Chief of Engineers for 1888.

In fig. 1, pl. 1, is shown graphically the changed level of mean low tide at Government Wharf from year to year since 1872, as far as data are available. The adopted plane of reference at this harbor is mean low tide as established by gauge readings near Government Wharf from October 2, 1872, to July 2, 1873. It will be observed that no records were taken for the months of July, August, and September, which would have been needed to complete a year's observations, but, as will appear from an inspection of fig. 2, pl. 1, during these three months the plane of mean low tide is much above mean low tide for the year; therefore our adopted plane of mean low tide is too low. The highest plane since determined was from records extending from May 1, 1887, to January 1, 1889, omitting from two complete years the months of January, February, March, and April, of which three are abnormally low-water months; consequently this plane was abnormally high. The plane of reference has at all times since 1873 been determined from an excellent bench mark upon the Hendley Building. Any settlement of this building—and it is believed that such settlement has been insignificant—would cause an apparent rise in plane of mean low tide; also, a rise would occur from diminished fluctuations at Government Wharf occasioned by the jetties. On the whole, therefore, paying due consideration to all suspected causes of change and error, it appears that the actual annual fluctuation of mean low tide is within limits of about 0.5 foot; that mean low tide as established in 1872–73 was about 0.19 foot below what it would have been if observations had been continued at the time throughout a complete year, and that

the net change of level of the Gulf of Mexico during the past twenty-four years has not been more than 0.1 or at most 0.2 foot.

Fig. 2, pl. 1, illustrates the monthly fluctuation of mean low tide during the two years ending June 1, 1896. In August, September, and October mean low tide may be expected to be something like 0.9 foot higher than in December, January, and February.

It is believed that the cause of the fluctuation shown in fig. 2 is the wind, the so-called trade winds of summer raising the level at this point.

One great source of difficulty in dealing with tidal data in this harbor is found in the small fluctuations, which give relatively great importance to all errors. Another source of difficulty is the great irregularity of all fluctuations, depending as they do so largely on the wind.

During the year time has been found to revise the data from which the curves shown in the last annual report were deduced. As a result of this revision, a part of the curves have been found unreliable, and the graphical illustrations accompanying this report have been made to supersede the plate of last year, as well as to show more recent data.

The plane of reference at Government Wharf gauge has been frequently checked by a line of levels from the Hendley Building bench mark. A monthly application of Mitchell's rule has served to check the relation between this plane and the zeros of the other two gauges.

DREDGING.

At the close of the last fiscal year dredging was in progress upon the outer bar under contract with Messrs. O'Connor & Smoot. A description of the plant used for this work will be found on page 1802, Annual Report Chief of Engineers for 1895. The contract price was 35 cents per cubic yard. Between July 1 and September 15, 1895, when work was suspended, 145,525 cubic yards was removed and dumped north of the line of the north jetty produced, and in 30 to 35 feet of water.

The total amount moved under the contract was 213,596 cubic yards.

On September 26, 1895, there was accepted from the Bucyrus Steam Shovel and Dredge Company the seagoing dredge *Gen. C. B. Comstock*, built for the United States at a cost of $86,000.

DESCRIPTION OF UNITED STATES DREDGE.

The hull, which is built of wood, coppered below the load line, was built at Perth Amboy, N. J., by Hugh Ramsay. It is 177 feet long over all, 35 feet 6 inches beam, and 16 feet depth of hold. The main engine is aft, and forward thereof, in order, come the boilers, the pumping engines, the after hopper, a compartment containing water tanks, and the forward hopper.

The hoppers do not extend to the ship's sides, but are contained between longitudinal bulkheads, with a slope favorable to rapid dumping. Twelve valves are located in the bottom of the hoppers. Each valve is hinged on the side next the keel and gives an opening 2 feet 10 inches by 3 feet 2 inches. These valves are controlled by hand from above deck. The contents ot the hoppers is a little over 600 cubic yards. The overflow is about 33 inches above the deck, upon which the water falls, to be conducted overboard through the scuppers.

The propelling engine is a fore and aft compound 20-inch and 36-inch diameter by 26-inch stroke. It was built by the Neafie & Levy Ship and Engine Building Company, of Philadelphia, Pa.

There are two marine boilers, each 10 feet in diameter by 11 feet 6 inches long. The working pressure is 90 to 100 pounds.

The dredging machinery consists of two of the Bucyrus Steam Shovel and Dredge Company's improved centrifugal dredging pumps, having 15-inch suctions and discharges. Each pump is driven by a directly connected compound condensing engine, having cylinders 12 inches and 22 inches by 14-inch stroke.

Each of the two suction pipes is 50 feet long. At the upper end is a cast-steel swivel elbow, connected with the upper stiff joint of the suction pipe by two hinge arms embracing a flexible rubber section. A second rubber section is introduced at a distance of 25 feet above the drag. Two styles of drag have been used. Those furnished with the boat are similar in design to the drag used on the *Charleston* at Charleston Harbor, South Carolina, except that on the *Comstock* the relief valves are at the top of the drags. Two drags have recently been purchased that are of the style used on the *Gedney*. But one of the latter has been in use. Thus far the indications are that the Edwards drag (similar to those on the *Gedney*) is superior in sand and the Bucyrus drag in mud and clay. Each suction pipe is raised and lowered by a steam crane, with wire-rope hoisting tackle. Vacuum gauges, connected with the suctions, are located conveniently to the winchman, for the purpose of indicating to the latter the state of affairs at the bottom of the drag and in the suction pipes.

The vessel is equipped throughout with electric lights, including search and boom lights. A Chase steam steering gear is in service and has given excellent results. The quarters of officers and crew are located over the hoppers and in a forecastle forward. Accompanying this report is a photographic view* of the dredge and a plate* of detail drawings kindly furnished by the Engineering News.

MATERIAL TO BE DREDGED.

In November, 1895, about 30 borings were made upon the bar, developing the fact that an irregular layer of clay from 4 to 10 or more feet thick was partially exposed in 22 to 24 feet of water between the jetties. The upper surface of the clay rises above the 30-foot contour at a point inside Galveston light-ship and descends below the 30-foot contour at a point near No. 2 buoy. The distance between these points in a line approximately parallel to the jetties and midway between them is about 2½ miles. In places this clay is largely mixed with sand and shell, and is more or less amenable to the scouring action of the tides. It became evident, however, that dredging over this part of the channel was absolutely necessary.

In general the outer crest of the sand bar proper has shown the least depth at any given time. The extreme fineness of the Galveston sand and the hard compact surface which it presents to the drag makes it, relatively to the sand at Charleston and Pensacola bars, difficult to raise rapidly and difficult to hold in the bins. Experiment shows that when allowed to fall through a salt water column 7 inches in height the average velocity of the Galveston sand particles is 0.67 inch per second as compared with 2.26 inches per second for sand from Pensacola, and 1.17 inches per second for sand from Charleston Bar.

The above velocities differ very little from final velocities and are functions of the diameters of the sand grains inasmuch as the proportions of silica and comminuted shell are about the same in all.

Experiment has shown that the ratio of the sand going overboard with the discharge to the sand held in the bins is as 2.8 to 5.

OPERATION OF DREDGE.

Considerable anxiety was felt as to the ability of the *Comstock* to dredge the stiff clay that occurred in places. It has been found, however, that if she be given way enough and the pumps be worked up to 225 revolutions per minute the clay comes up in lumps as large as 6 or 8 inch cubes, that the bins are filled quicker than when sand is dredged, and that there is no trouble whatever in dumping. The makers of the pumps advised a speed of 185 revolutions per minute. Experience has shown, however, that the "rate per minute" has been increased more than 50 per cent by increasing to 225 revolutions per minute, and the latter speed is now maintained at all times in sand as well as clay.

When the weather has permitted, work has been confined to the outer crest of the bar. The dredged area here is about 4,200 feet long by 300 feet wide. The shifting nature of this part of the channel, and the fact that it is in the path of sand projected out by the jetties seem to prevent the maintenance of much greater depths than those due to scour. It is clear, however, that the whole area of the bar must be deepened to some extent by the dredging, and in time the channel itself must experience permanent improvement.

When the weather is too rough for dredging on the outer crest, work has been done in the exposed clay and in the sand and shell that lies between the light-ship and the outer crest. This part of the channel is 7,200 feet long by 300 feet wide. When rough weather has prevented dumping outside the jetties, rather than lose time at anchor, material has been dumped against the south side of the north jetty. The center line of the dredging is shown on the map accompanying your report. The dump grounds are indicated on Pl. II accompanying this report. Below are given further details of the dredging in tabulated form:

Résumé of work done by U. S. dredge Gen. C. B. Comstock from September 9, 1895, to June 30, 1896.

	Time.	
	h.	*m.*
Effective working time	1,751	17
Delays for bad weather	772	11
Delays for repairs	641	56
Delays for other causes	349	35
Idle on account of Sundays and holidays	503	10
Total time made	4,018	09

* Not printed.

Distribution of working time.

	Time.	Per cent.
	h. *m.*	
Anchorage to cut	113 43	6
Pumping	1,076 37	62
Cut to dump	185 04	11
Dumping	95 56	5
Dump to cut	159 53	9
Dump to achorage	101 54	6
Time lost turning	18 10	1
Total	1,751 17	100

Ratio of pumping to transporting		1.6 to 1
Number of loads dredged		774
Quantity of material dredged:		
Sand	cubic yards	201,243
Mud	do	218,505
Average monthly output	do	43,407
Output per hour of digging	do	389.4
Average amount dredged per minute in sand	do	5.5
Average amount dredged per minute in mud	do	7.8

Cost per cubic yard.

Wages	$0.0297
Subsistence	.0088
Fuel	.0162
Oils, waste, etc	.0031
Miscellaneous supplies	.0021
Maintenance	.0043
Extraordinary repairs	.0098
Total cost per cubic yard	.0740

Average cost per ton for fuel		4.78
Average amount of fuel burned per cubic yard dredged	pounds	7.57

Prior to May 23, 1896, the dredge was worked twelve hours each day with a single crew consisting of—

	Per month.		Per month.
1 captain	$125	2 oilers each	$45
1 mate	90	4 firemen do	40
1 mate	60	2 winchmen do	40
1 steersman	75	1 watchman	35
1 carpenter	70	4 seamen each	35
1 recorder	40	1 cook	50
1 engineer	120	1 cabin boy	20
1 engineer	80	1 cabin boy	15
1 engineer	60	1 laundress	10

Since May 23, 1896, the dredge has worked twenty-four hours each day with a double crew consisting of—

	Per month.		Per month.
1 captain	$125	6 firemen each	$45
1 mate	90	2 coal passers do	40
2 mates each	60	4 winchmen do	40
1 steersman	75	1 watchman	35
1 steersman	60	8 seamen each	35
1 carpenter	70	1 cook	50
1 recorder	40	1 cook	30
1 engineer	120	1 cabin boy	20
1 engineer	80	1 cabin boy	15
2 engineers each	60	1 laundress	10
4 oilers do	45		

JETTY CONSTRUCTION.

Having in mind its possible value in future undertakings similar to the jetty work at this harbor, I give below certain details as to the plant used in their work by Messrs. O'Connor, Laing & Smoot, the jetty contractors, and certain details as to the procurement of their supply of stone. The sandstone is brought on ordinary flat

cars directly from the quarry to the point upon the trestle where it is to be unloaded by hand into the jetty. The granite blocks for south jetty are taken out upon the trestle in the same manner, but the unloading is done with a large floating derrick. The granite blocks for north jetty are brought by rail to Clinton, where they are loaded by means of a fixed derrick onto barges. These barges are towed through Buffalo Bayou and Galveston Bay, about 50 miles, to the site of the north jetty, and unloaded by floating derrick. Preliminary to the unloading of any stone is the construction in advance of the standard-gauge railway upon trestlework. Subsequent to the unloading of the stone the work consists of placing in a regular and proper manner the granite blocks that have been temporarily resting one upon another on the shoulders of the jetty. This placing is done with the same floating derricks used for unloading, and to some extent with a track derrick. At all times the contractors are engaged at their own expense, except in cases of extraordinary damage from storms, in renewing the supports of the railway and repairing the trestle generally. The life of a pile in the waters of this harbor is but little over a year on an average. A track driver and about 30 men are constantly engaged upon this work of maintenance of trestle and a large amount of material is used. Sometimes the caps are blocked up from the granite blocks below, and sometimes short piles are driven into the jetty some 6 or 8 feet, following the teredo-eaten piles they are designed to replace. A monthly rate of pay prevails in case of the regular crews of derrick barges, tugboats, etc. Pile-driver men, switchmen, trackmen, locomotive engineers, firemen, etc., are paid by the hour. The unloading of sandstone is paid for at the rate of 75 cents per car of about 22 tons. One man can unload from 2 to 3½ cars per day.

To do the work as above outlined, the contractors have in present use the following plant:

Steam tugs:	
Hortense.—Twin-screw steel vessel, 102 by 21 feet by 8 feet 6 inches depth of hold and 65 tons net register; two compound condensing engines, cylinders 13 and 25 inches by 18-inch stroke; nominal horsepower, 300; screw propellers, 6 feet 6 inches diameter; draft, 7 feet 6 inches; speed, light, 12 knots; electric search light and incandescent lamps throughout; built at Philadelphia, 1893; cost	$38,000
New Brunswick.—Wooden hull, 60 by 14 by 8 feet depth of hold; 21 tons net register; one condensing engine 16 by 18 inches; built at Mobile, 1891; cost	8,500
Granite barges:	
Five model barges, 172 by 32 feet by 9 feet 6 inches; built of selected sticks long-leaf yellow pine; capacity, 650 tons deck load; cost, each, $12,000	60,000
One scow-built barge, 130 by 31 by 7 feet; capacity, deck load of 300 tons; cost	7,500
Derrick barges:	
One 165 feet by 28 feet 6 inches by 7 feet 6 inches, and one 150 by 36 by 10 feet; each equipped with stiff-leg revolving derrick over stern of vessel and stiff-leg derrick at side of bow; all derricks of 20 tons capacity and operated by double-cylinder 30 horsepower engines, geared to higher power on three drums each derrick; cost, $17,500 and $15,000	32,500
Cram steam pile-driver (automatic) on one derrick barge; cost	2,500
Transfer barge: One model barge, wooden hull, 145 by 35 feet by 8 feet 6 inches; equipped with 3 parallel railway tracks; capacity, 9 to 10 standard cars, each loaded with 25 tons; cost	10,500
Water barge: Model barge, wooden hull, 100 by 24 feet by 7 feet 6 inches; equipped with boiler, pump, etc.; cost	6,000
Locomotives:	
No. 1, Baldwin, 39 tons, saddle tank, built 1885; cylinder 14 by 22 inches, secondhand	4,000
No. 2, Baldwin, 40 tons, built 1889; cylinders 17 by 22 inches	7,250
No. 3, Baldwin, 32 tons, built 1887; cylinders 12 by 20 inches	6,500
No. 4, Schenectady, 38 tons, built 1885; cylinders 15 by 24 inches	3,500
Miscellaneous:	
Steam railroad pile driver, to drive 80-foot piles	3,750
Steam railroad pile driver, ordinary	1,500
Steam derrick car, capacity 10 tons	2,750
Five material and flat cars, each $200	1,000
One inspection car	450
One inspection coach	1,200
Railroad track and wharves: At Fort Point and Bolivar for switches, yards, siding on south jetty, and for transferring cars across the gorge, 40,464 linear feet of track and trestle, and two slips complete, with cradles and hoisting apparatus	113,586

Buildings, tanks, etc.: Offices and warehouses at each jetty, machine shop, boat shop, boarding house, water tanks, and coal bins, north jetty; water tank and coal bin, south jetty		$10,150
Machinery and plant, granite quarry:		
Five 20-ton derricks	$4,000	
Two 20-horsepower double-cylinder double-drum engines	2,100	
Two 25-horsepower double-cylinder double-drum engines	2,400	
One 16-horsepower double-cylinder double-drum engine	825	
One Ingersoll drill	375	
Three steam drills	600	
Two boilers, for drills	450	
Pumping plant, steam pipes, and tools	2,500	
		13,250
Machinery and plant, sandstone quarry:		
Four hoisting engines	3,200	
Eight derricks	3,600	
Three steam drills	600	
Two drill boilers	500	
Pumps, drills, tools, tackle, etc	3,000	
Nine teams mules. scrapers, wagons, etc	3,600	
		14,500
Railroad spurs and switches to quarries: Grading and bridging 26.75 miles		21,400
In addition to above plant owned by O'Connor, Laing & Smoot, the plant of four subcontractors has been in use, distributed at four quarries, and estimated to have cost		27,985
Total cost of plant, as detailed above		398,271

I am obliged to Messrs. O'Connor and Smoot for much of the information given above.

It is to be understood that I have given their figures for cost, although many of the items were the subject of discussion between us. The actual value of the plant is of course much less than the figures given above.

The contractors have gotten part of the stone from their own quarries, and have purchased the rest from others. The length of haul for granite has been 294 miles, and for sandstone from 130 to 206 miles. The following typical conditions of cost obtain in the case of supplies of sandstone from Millican and granite from Granite Mountain. The figures are obtained from the contractors and from various other sources. The freight charges given below are from 20 to 40 cents per ton less than they were during earlier periods of the work.

Sandstone from Millican.—Quarry lies 2½ miles south of Millican, Tex., and 132½ miles from Galveston; covers about 75 acres; rock from 6 to 14 feet thick; strippings less than 1 foot; character of stone, excellent; a flinty sandstone, weighing 135 to 145 pounds per cubic foot. O'Connor, Laing & Smoot expended $5,000 in grading spur to quarry, agreeing to take 5,000 cars. Subcontractors pay royalty of from 10 to 25 cents per car.

Cost to O'Connor, Laing & Smoot, at Galveston:

Riprap loaded on cars, per ton	$0.50
Expense of grading, per ton	.04
Freight	1.05
Wharf company (50 cents per car trackage)	.02
	1.61

To above must be added the contractors' office expense, losses from culling, switching, repair to trestle, fixed charges and cost of unloading. At present the cost of maintaining their switches, grades, and wharves, as well as the trestle upon the jetties, is about $50,000 per annum. The contractors receive $2.35 per ton for this sandstone in place.

Granite from Granite Mountain.—The mountain is an upheaved mass of red granite of superior quality as a building stone. It rises some 200 feet above the general level of the ground and covers nearly 100 acres.

The distance to Clinton on Buffalo Bayou is 248 miles, and to Galveston 294 miles. Part of the granite is unloaded on the contractors' barges at Clinton, and part is brought directly to the jetties on cars. The through rate to Galveston is about $1.90 per ton; to Clinton, $1.60 per ton.

Cost to O'Connor, Laing & Smoot, at Galveston:

Royalty per ton	$0.075
Quarrying and loading	.43
Grading of right of way	.01
Freight	1.90
Wharf company, Galveston, trackage	.02
	2.435

To the above must be added fixed charges, office expenses, losses from culling, switching, repairs to track and trestle, and cost of unloading and placing. The expense of unloading and handling is vastly greater for granite than sandstone, and it is probable that the profit of the contractors is considerably less than $1 per ton on granite as compared with less than half as much on sandstone. Earlier in the contract their profits were less than this, and they may well be less again, as the advance of the jetties naturally adds to exposure of plant and loss of time.

It is believed that the contractors, Messrs. O'Connor, Laing & Smoot, are deserving of commendation for the able manner in which they are handling this work.

Accompanying this report are photographic views,* one illustrating a section of completed work, and one showing a derrick barge unloading granite from cars on south jetty.

The details of the work for the past year are given in the report of Assistant Engineer E. M. Hartrick, forwarded herewith.

CONDITION OF JETTIES.

Since the commencement of work under the present project there has been no damage to completed work, either through displacement of material by waves or through excessive settlement. With the exception of a few cars of riprap unloaded where an experimental clay core has been used, no repairs have been made or are now needed throughout the nearly 11 miles of completed work. I insert here a table showing the average amount of subsidence in each 1,000 linear feet of jetty. The levels were run along center line of jetties.

Subsidence of jetties.

[Figures show elevations in feet above mean low tide.]

Stations.	North jetty.				South jetty.				
	First levels taken after construction.		June, 1894.	May, 1896.	July, 1890.	Jan., 1891.	Nov., 1893.	Apr., 1895.	May, 1896.
0 to 10	July, 1893	6.42	6.34	6.10	5.96	5.73	.....	5.55	5.80
10 to 20	Aug., 1893	5.60	5.37	5.29	6.23	5.65	.....	5.33	5.53
20 to 30	Sept., 1893	4.92	4.90	4.90	6.32	6.27	6.27	5.69	6.02
30 to 40	Oct., 1893	5.32	4.98	4.88	6.42	6.34	6.07	5.24	5.98
40 to 50	Nov., 1893	5.43	4.92	4.85	6.43	6.40	6.23	5.90	6.25
50 to 60	Dec., 1893	5.34	5.17	5.00	6.42	6.41	6.18	5.82	6.13
60 to 70	...do	5.56	5.34	5.22	.....	5.86	.....	5.76	5.83
70 to 80	Feb., 1894	5.68	5.49	5.27	6.29	6.20	5.93	5.60	5.60
80 to 90	May, 1894	5.91	5.71	5.59	5.74	5.73	5.70	5.59	5.19
90 to 100	June, 1894	5.60	.....	5.44	5.90	5.92	5.83	5.45	5.57
100 to 110	.....do	5.41	.....	5.08	5.93	5.91	5.89	5.89	5.65
110 to 120	Feb., 1895	5.21	.....	4.96	6.27	6.07	5.90	5.10	5.31
120 to 130	.....do	4.98	.....	4.77	6.51	6.47	4.90	6.40	6.14
130 to 140	Apr., 1895	5.10	.....	4.74	6.40	6.31	6.10	6.10	5.96
140 to 150	.....do	4.90	.....	4.71	5.56	5.55	5.44	5.36	5.27
150 to 160	.....do	5.20	.....	4.79	5.53	5.50	5.39	5.30	5.27
160 to 170	May, 1895	5.34	.....	4.88	5.53	5.33	5.28	5.24	5.17
170 to 180	.....do	5.00	.....	4.75	6.02	5.92	5.88	5.83	5.75
180 to 190	June, 1895	5.44	.....	4.98	.....	6.17	5.90	5.68	5.60
190 to 200	Nov., 1895	5.40	.....	5.16	.....	.....	5.01	4.75	4.66
200 to 210	Dec., 1895	5.26	.....	4.74	.....	.....	.....	4.86	4.83
210 to 220	.....do	4.87	.....	4.51	.....	.....	.....	5.05	5.04
220 to 230	.....	.....	.....	.....	.....	.....	.....	4.53	4.45
230 to 240	.....	.....	.....	.....	.....	.....	.....	4.77	4.66
240 to 250	.....	.....	.....	.....	.....	.....	.....	4.49	4.41
250 to 260	.....	.....	.....	.....	.....	.....	.....	4.74	4.70
260 to 270	.....	.....	.....	.....	.....	.....	.....	5.09	4.95
270 to 280	.....	.....	.....	.....	.....	.....	.....	4.98	4.90
280 to 290	.....	.....	.....	.....	.....	.....	.....	5.61	5.45
290 to 300	.....	.....	.....	.....	.....	.....	.....	5.84	5.63
300 to 310	.....	.....	.....	.....	.....	.....	.....	5.27	5.00
310 to 320	.....	.....	.....	.....	.....	.....	.....	4.49	4.28

NOTE.—From Station 0 to 130, south jetty, some stones were moved during 1895, the contractors repairing their track. March 19, 1895, 20 cars of stone were unloaded between Stations 121 and 131.

*Not printed.

SCOUR ON BAR.

Plate II, accompanying this report, shows an area between and beyond the jetties that has been divided into squares 1,000 feet on a side. In each square is a figure indicating the average depth in feet of fill or scour that occurred within its area between survey made in June-July, 1894, and January-February, 1896. A table is inserted below giving the results of this same comparison in tabulated form. The area considered is the same as shown in Plate II. It was soon after the survey of June-July, 1894, that the period of rapid improvement began. This improvement has continued beyond the time of the survey of January-February, 1896, and is still in evidence.

Scour and fill between and beyond jetties for area shown on Plate II.

	Excavation.	Fill.	Net excavation.	Net fill.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
Between jetties	13,036,068.6	1,652,405.7	11,383,662.9	.....
Between line of jetties produced	1,027,776.3	4,259,257.1	.....	3,231,480 8
North of north jetty axis produced	1,694,444.1	499,999.8	1,194,444.3	.....
South of south jetty axis produced	842,592.1	1,314,813.9	.....	472,221.8
Total	16,600,881.1	7,726,476.5	12,578,107.2	3,703,702.6

Net excavation, or dispersal of material from area covered by comparative surveys, 8,874,404.6 cubic yards. During this period 325,917 cubic yards were removed from between the jetties by dredging. This material was dumped, as shown on Plate II, in the area north of axis of north jetty produced.

Very respectfully, your obedient servant,

W. V. JUDSON,
First Lieutenant, Corps of Engineers.

Maj. A. M. MILLER,
Corps of Engineers, U. S. A.

REPORT OF MR. E. M. HARTRICK, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., June 30, 1896.

SIR: I have the honor to submit the following report of operations for improving Galveston Harbor, Texas, during the fiscal year ending June 30, 1896:

SOUTH JETTY.

At the time of suspension in 1893 this jetty was completed to Station 320, with an apron to Station 328+39. At end of the present fiscal year the jetty is completed to Station 331, an advance of 1,100 feet. The riprap mound is to mean low tide at Station 337; apron and trestle at Station 350, an advance gulfward of 2,161 feet.

The condition of south jetty over that part of the work which had been completed and then suspended in June, 1893, remained about the same except general settlement and consolidation, especially at the outer end, between Stations No. 318 and 320, where scour undermining the mound, assisted by wave action, caused settlement or consolidation of from 1½ to 2 feet, and over the riprap apron from 3 to 8 feet.

When work was suspended in 1893 the riprap for the apron was being deposited in an average depth of 15 feet, but when work was resumed in 1895 it was deposited in an average depth of 23 feet. This portion of the work is on the sandy bottom of the Gulf with no mattress foundation, as it was found that the deterioration and compression of mattress work counterbalanced the extra cost of stone and its settling in the shifting sand.

The construction trestle for the delivery of stone and transportation of labor, and which had to be repaired and renewed, as explained in last annual report, was completed in July, 1895, to Station 315+98. The Government then took charge of the work and continued it by day labor to Station 320+64, and for the rest of the exten sion at regular contract prices. The work between Stations 195 and 315+98 was done in an unworkmanlike manner and with very inferior piles, necessitating constant repairs, delaying the forwarding of material to the front, and retarding the progress of the work.

TABLE NO. 1.—*Showing kind and amount of stone placed in south jetty.*

Month.	Cars.	Riprap.	Cars.	Block.	Total cars.
1895.		*Tons.*		*Tons.*	
August	78	1,653.44	.....	.....	78
September	333	6,886.93	.....	.....	333
October	319	6,825.06	.....	.....	319
November	629	13,538.92	63	1,365.92	692
December	311	6,714.36	41	838.69	352
1896.					
January	308	6,486.15	240	5,460.50	548
February	322	7,059.16	346	8,032.35	668
March	1,190	26,060.88	120	2,698.54	1,310
April	125	2,887.37	75	1,745.76	200
May	274	6,213.62	117	2,810.58	391
June	282	6,169.28	482	11,780.68	764
Total	4,171	90,495.17	1,484	34,733.02	5,655

TABLE NO. 2.—*Showing average cost per linear foot between stations.*

[Cost does not include office and inspection expenses.]

Stations.	Distance.	Average depth of water.	Cost per linear foot.	Remarks.
	Feet.	*Feet.*		
0 to 79+64	7,964	.....	$19.46	Shore connection across old channel; average height, 1.07 feet above mean low tide.
79+64 to 84+64	500	3	34.28	Shore branch.
84+64 to 95+64	1,100	2.45	28.54	
95+64 to 107+64	1,200	1.50	36.52	Clay core.
107+64 to 138+64	3,100	5.70	72.37	Do.
138+64 to 144+12	548	9.50	73.54	Do.
144+12 to 150	588	7.50	60.54	
150 to 160	1,000	7.30	56.64	
160 to 170	1,000	8.65	55.68	
170 to 180	1,000	7	40.53	
180 to 190	1,000	7.50	43.78	
190 to 200	1,000	10.95	79.85	Granite protection from Station 194.
200 to 210	1,000	10.35	81.36	
210 to 220	1,000	9.60	76.12	
220 to 230	1,000	7	72.70	
230 to 240	1,000	8.70	76.81	
240 to 250	1,000	9	80.65	
250 to 260	1,000	9.30	82.95	
260 to 270	1,000	10.20	89.91	
270 to 280	1,000	9.10	80.11	
280 to 290	1,000	9.20	74.24	
290 to 300	1,000	9.10	78.50	
300 to 310	1,000	10.10	78.93	End of mattress work.
310 to 320	1,000	16.50	136.07	Sand foundation.
320 to 330	1,000	23	*198.05	Old apron 320–328+39.
330 to 340	1,000	23.5	156.35	Granite unloaded to Station 336, only placed to 331.
340 to 350	1,000	22.9	47.31	Apron.

*Due to scour alongside at the toe and ahead of the apron; between June, 1893, and August, 1895.

NORTH JETTY.

The condition of work on north jetty at beginning of fiscal year was as follows: Jetty complete to Station 185, riprap mound to mean low tide at Station 201, trestle track and apron at Station 225. At the end of fiscal year the jetty was complete to Station 233, an advance of 4,800 feet; riprap mound to mean low tide at Station 234; apron and trestle at Station 251+10, an advance of 2,610 feet.

Although the construction trestle and track on this jetty is in better repair than that on south jetty, it is nevertheless in a very dangerous state, it being difficult to determine the condition of the bearing pile before the bent actually collapses, as the pile is surrounded with riprap and block, where the teredo does its most active work and is out of sight of the track gang. The only safe method of repairs would be by constant renewal of piles over one year in the work.

TABLE NO. 3.—*Showing kind and amount of stone placed in north jetty.*

Month.	Cars.	Riprap.	Cars.	Block.	Total cars.
1895.		*Tons.*		*Tons.*	
July	460	10,296.52	612	14,473.20	1,072
August	626	13,450.64	337	8,101.53	963
September	247	5,521.90	497	11,458.17	744
October	661	14,736.92	456	10,635.62	1,117
November	371	8,159.09	325	7,405.90	696
December	564	11,818.32	238	5,138.46	802
1896.					
January	954	21,260.36	412	9,259.20	1,366
February	440	9,755.73	182	4,061.03	622
March	249	5,686.13	369	8,953.48	618
April	320	7,122.57	371	9,215.79	691
May	275	6,564.01	407	9,681.70	682
June	586	12,907.62	126	3,064.51	712
Total	5,753	127,279.81	4,332	101,448.59	10,085

TABLE NO. 4.—*Showing average cost per linear foot between stations.*

[Cost does not include office and inspection expenses.]

Stations.	Distance.	Depth of water.		Cost per linear foot.	Remarks.
		Max.	Min.		
	Feet.	*Feet.*	*Feet.*		
0 to 15	1,500	.....	.....	$15.53	Shore branch.
15 to 20	500	8	0.5	35.68	Granite on crest; none on slope.
20 to 30	1,000	11	7.5	67.65	Granite on crest and on slope from station 24.
30 to 40	1,000	11.5	9	69.60	
40 to 50	1,000	11.5	9.5	71.27	
50 to 60	1,000	11.5	6.5	66.53	Quicksand reef.
60 to 70	1,000	8	5	70.06	Do.
70 to 80	1,000	9	6.5	76.51	Do.
80 to 90	1,000	12.5	9	100.96	
90 to 100	1,000	15	11	113.34	
100 to 110	1,000	19	15	124.82	
110 to 120	1,000	18	16.25	126.90	
120 to 130	1,000	21	17.25	138.88	
130 to 140	1,000	19	16	128.28	
140 to 150	1,000	16.5	16	135.83	
150 to 160	1,000	16.5	15	122.96	
160 to 170	1,000	16.4	16.10	125.99	
170 to 180	1,000	19	16	152.95	
180 to 190	1,000	17	15.5	148.89	
190 to 200	1,000	19	11.5	154.25	Outer bar.
200 to 210	1,000	13.5	7.5	151.48	
210 to 220	1,000	18	8.5	162.43	As the work progressed there was thrown up a small ridge of sand; the original depth over the bar at the axis of this jetty was 11 feet.
220 to 230	1,000	22.5	21.5	*281.97	
230 to 240	1,000	24.5	21.5	184.34	Granite unloaded to station 235.
240 to 250	1,000	28	24.5	36.66	Apron.

*The riprap mound before it had been protected on its slope was washed down and flattened, requiring more riprap to build it up and more granite to cover it.

CASUALTIES ON BOTH JETTIES.

Easterly gales, accompanied with heavy seas, on the 28th, 29th, and 30th of August, 1895, carried away several hundred feet of trestle and track at the outer end of both jetties, leaving in some places only about half the piles standing, and the adjoining track in such a condition that it required a thorough overhauling. The work was also retarded in November, 1895, by rough seas, rain, and cold weather and repairs needed, and again in December, 1895. Equinoctial gales in March, 1896, and heavy seas on the 11th and 12th of April, 1896, damaged trestle and track. In March, 1896, the pile driver extending the trestle on south jetty was turned over and wrecked in 22 feet of water by the uneven settlement of the piles in the last bent that had been constructed. A diver was found necessary to recover the machinery and trucks; the framework had all to be renewed.

INSPECTION, CONSTRUCTION, TRANSFER, AND BARGE LINE.

The general method of inspection and construction remains the same as explained in previous reports, except when the exigency of the case demands; then it is modified to suit the occasion. The inauguration of the present contract was in 1891. (See Appendix U, Report of Chief of Engineers for 1892, where the general construction over the mattress work on south jetty is explained.) The method of transfer between Fort Point and Bolivar Point when the north jetty was started was explained in Appendix U, Report of Chief of Engineers, 1893, and the barge line between Clinton and Bolivar was explained in Appendix U, Report of Chief of Engineers, 1894, except that the reweighing by displacement of the barges as they arrived on the work had to be abandoned as impracticable, the same barge at different times with nearly equal tonnage giving very different results according to the way the load had been distributed over its deck at Clinton.

GENERAL PROGRESS AND ADVANCE OF THE WORK.

The work on both jetties has been retarded by inadequate mechanical appliances and steam power, lack of "liberal supply of all kinds of material on hand at all times," and the constant repairs to machinery and construction trestle. As mentioned in my last report, the insufficient machinery and steam power in handling granite blocks gave trouble and caused delay. So it was this year, and it became more obvious in February, 1896, when the 10-ton block was the lightest permitted to be unloaded on the work, except a few blocks for repairs in the 5 to 10 ton section. These delays will continue and become more pronounced as the jetties advance into the open Gulf and less lee is provided against heavy seas and swells from the easterly quadrant. The want of another pile driver was clearly demonstrated when the accident happened to the driver at the front, as before mentioned. There was no other pile driver available for this work; therefore considerable time was lost (together with the partial shutting down of the quarries) for want of an extra suitable pile driver which could also be used on the constant repairs required on both jetties and transfer wharf. After the wrecked pile driver had been put in order, instead of extending the jetties gulfward it was used for some considerable time in repairs to trestle, track, and transfer.

DREDGING ON THE OUTER BAR.

On the night of the 15th of September, 1895, the dredge *Jumbo* was removed from the outer bar on account of the United States dredge *Gen. Comstock* becoming available for the work. The dredge *Jumbo* did better work toward the end of the contract, as a more powerful tug was provided whereby a greater number of loads were removed. A wharf and a coal bin with a capacity of 1,000 tons were erected at Fort Point in July, 1895, for the United States Government dredge and dispatch boats.

Borings over the outer and inner bar were made in November, 1895, to determine the character of material that had to be removed and the thickness of sand, silt, mud, or clay that had to be dredged or scoured before 30 feet of water could be obtained. By these borings its was ascertained that the bar was not all quicksand, and that underlying it was a silt or clay.

TABLE NO. 5.—*Showing amount of material removed by dredge Jumbo.*

	Loads.	Cubic yards.
July, 1895	56	32,689
August, 1895	98	63,882.90
September, 1895	76	48,944.30
Total	230	145,525.20
Previously removed (April, May, and June, 1895)	125	68,071.20
Total	355	213,596.40

SURVEYS.

A deep-water survey which embraced the 40-foot curve of depth outside the bar to the 30-foot inside and extended 1½ miles on each side of the jetties, covering an area of about 15 superficial miles, was made in January and February, 1896. The notes were platted and chart forwarded.

Monthly surveys of the outer bar were made regularly every month, weather and sea permitting. In April and the beginning of May, 1896, the continued strong easterly

winds accompanied with heavy seas and swell prevented reliable soundings from being taken. By comparing the monthly charts, it will be seen that the partial deepening on the bar only began when the north jetty had been extended 2 miles gulfward, and was being constructed over the outer bar to nearly the same distance out as the south jetty.

The annual survey was started the latter part of April and carried on through May and June, 1896. It covers the area from the 12-foot curve in Galveston Bay, including Pelican Island and Spit, to the 30-foot curve in the Gulf of Mexico, with shore lines from Baffle Point to Station P, on Bolivar Peninsula, and on Galveston Island from the west end of Galveston Wharf, on the bay, to Fort Point; thence along the Gulf shore to Twenty-fifth street.

The Gulf and bay shores on Galveston Island, Bolivar Peninsula, Pelican Island and Spit remain about the same as last year. The shoal between Fort Point and light-ship north of south jetty has extended gulfward, the 6-foot curve 1,400 feet, and the 12-foot curve 600 feet. Bird Island Shoal, south of Bolivar Point, remains in the same condition as before.

On the north side of both jetties sand continues to deposit against the mound, forming a water-tight embankment. On the south side of south jetty, and on the south side of north jetty, east of Bird Island Shoal, off station 100, the banking of sand is not so pronounced as on the north side. From station 100, easterly along the south side of north jetty to the bar, there is an increase of depth with the 18-foot curve impinging against the mound for a length of 11,500 feet. The 24-foot curve inside has a decided tendency toward north jetty, having advanced over 500 feet in that direction. North of north jetty the 12 and 18 foot curves remain unchanged with the 24-foot curves receding westerly 600 feet. South of south jetty the 12, 18, and 24 foot curves have receded westerly from 400 to 800 feet. Between the jetties and their proposed extension the following is observed: The 18-foot channel is connected with the Gulf of Mexico, having a width of 800 feet, and 500 feet between the 20-foot curves. The 24-foot channel, although not connected with the Gulf, shows a decided tendency to open up. The average channel course across the bar is SE. by E. $\frac{1}{2}$ E. On this course, for a distance of 1,200 feet, there is a good 24-foot channel, except in spots, where there is 23$\frac{1}{3}$ feet, and in one place 22 feet, which of course must be the ruling depth at the time of this report. This channel, at its gulfward approach, has a tendency to the southeast.

Measuring on the axis of the channel, as above, the 24-foot curve has advanced easterly inside the bar 3,500 feet, and outside 800 feet. The 30-foot curve remains about the same inside and out on this axis. On the axis of north jetty the 24-foot curve has receded westerly 700 feet, and the 30-foot curve advanced easterly 1,100 feet. On the axis of south jetty the 24-foot curve has advanced 450 feet, the 30-foot curve remaining about the same.

Galveston Channel remains unchanged, with 24 feet on the inner bar.

Accompanying this report is a comparative map showing the curves of depth as they were when the present project of 1886 was adopted and before work was started in 1887 and the survey of 1896.

The surveys were made in April and May, 1887, and in April, May, and June, 1896. The most important changes observed are as follows: Pelican Spit has moved south and west from 400 to 600 feet. Bolivar Gorge and Bird Island Reef between Bolivar and Fort Point have moved southerly from 100 to 300 feet. The reef north of south jetty between Fort Point and the light-ship has advanced gulfward 1,000 feet, the 6, 12, 18, and 24 foot curves hug one another, and Fort Point, abreast of Buoy No. 5 at the approach to Galveston Channel from the east.

The area in the angle formed by south jetty and the Gulf shore at Fort Point is rapidly filling up, the accretion having advanced over 6,000 feet at its northeasterly extremity, but has eroded from 50 to 200 feet between First and Tenth streets. Formerly where there had been a succession of channels, ponds, marshes, and islets between Galveston City and Fort Point there is now comparative dryness with a continuous shore line and the "Hospital Channel" nearly obliterated.

Comparing the curves of depth between the jetties and their proposed extension the following is observed: The 30-foot curve inside the bar has advanced gulfward 2,400 feet, outside it has advanced more on the axis of north jetty than on south jetty, but will average 2,400 feet. The 24-foot curve from inside has advanced 6,300 feet, outside on axis of present channel 3,300 feet, but on each side of the jetties only from 400 to 800 feet. The 18-foot curve inside has advanced and joined the curve in the Gulf of Mexico. The 18-foot curve outside the bar has receded 700 feet on the south side of south jetty, and has advanced 1,600 feet on the north side of north jetty. The 12-foot curve outside has receded westerly 900 feet on the south side of south jetty, and advanced 2,000 feet on the north side of north jetty.

The 18-foot trench alongside and south of south jetty between stations 228 and 300 filled in during 1892.

The distance between the 24-foot curves on the inner bar was 3,900 feet; it is own 50 feet.

TRUE MERIDIAN

B O L I V A R Pt.

LIGHTHOUSE

PELICAN SPIT

LIGHTHOUSE

G A L V E S T O N

CHANNEL

THE 6 FOOT CONTOUR IS SHOWN THUS
.. 12 .. ..
.. 18 .. ..
.. 24 .. ..
.. 30 .. ..
COMPLETED JETTY .. ..
JETTY TO M. L. T. .. .. ..
APRON .. .. ..
JUNE 30, 1896.
SURVEY OF 1887 IN BLUE
.. .. 1895 IN RED
.. .. 1896 IN BLACK

GALVESTON HARBOR TEXAS

Comparative contours from surveys of

1887, 1895 & 1896

SCALE OF FEET
2000 0 1000 2000 3000 4000 5000 6000

GALVESTON, JULY 15 1896.

RESPECTFULLY FORWARDED WITH ANNUAL REPORT FOR FISCAL YEAR ENDING JUNE 30TH. 1896.

A. M. Miller
MAJOR, CORPS OF ENGINEERS.

ANDREW B. GRAHAM, PHOTO-LITHO, WASHINGTON, D.C.

Eng 54 2

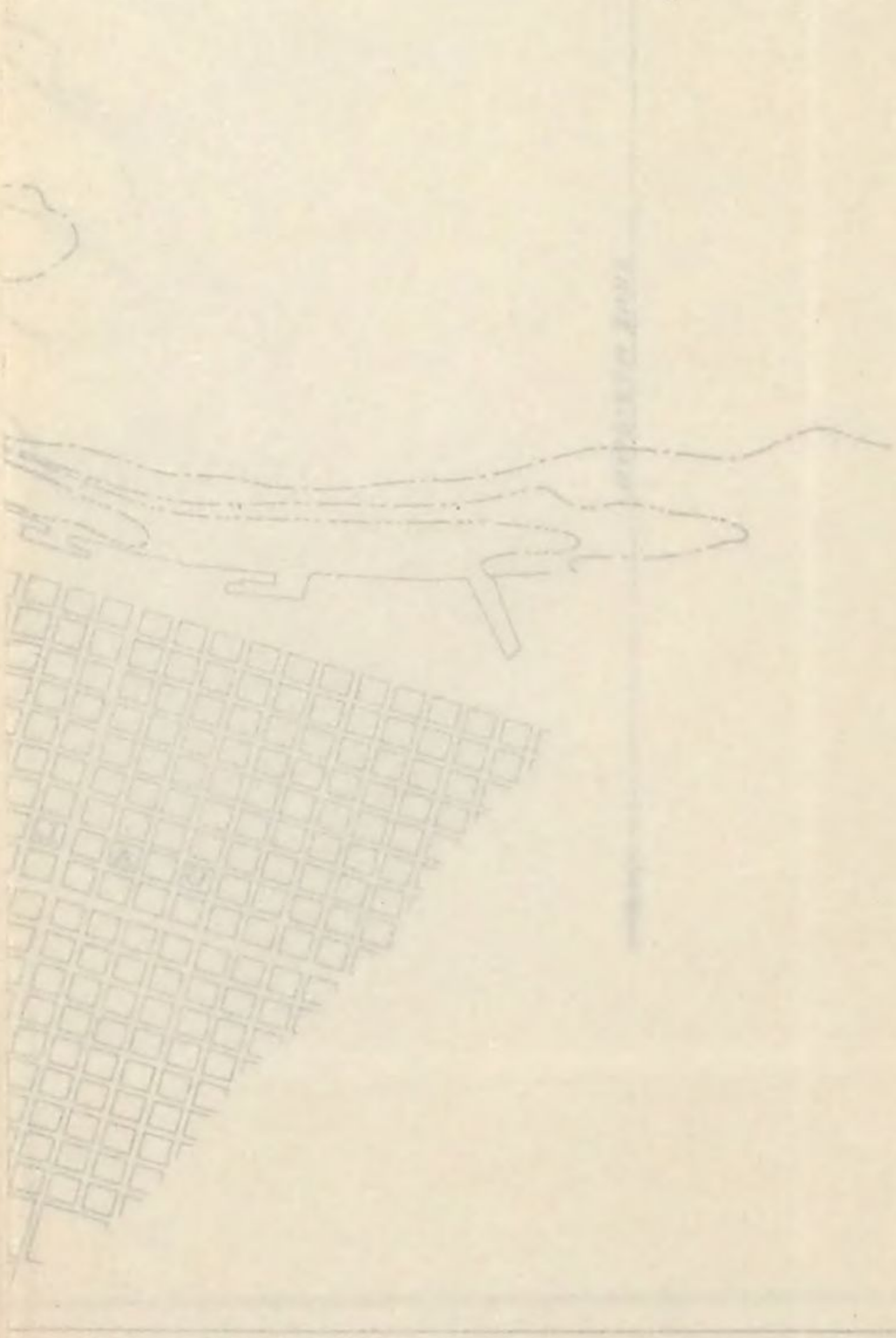
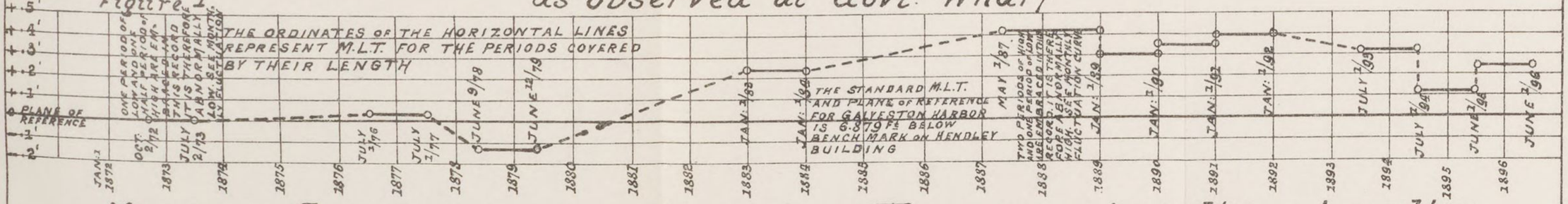


PLATE I

TIDAL DATA OF GALVESTON HARBOR

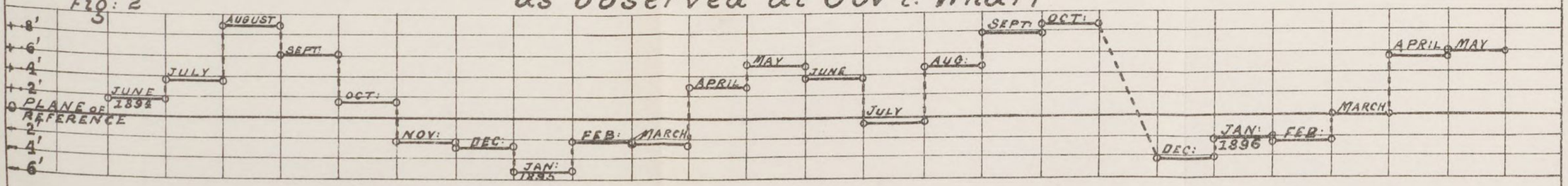
ANNUAL FLUCTUATION OF MEAN LOW TIDE FROM 1872 TO 1896
as observed at Gov't: Wharf

Figure 1



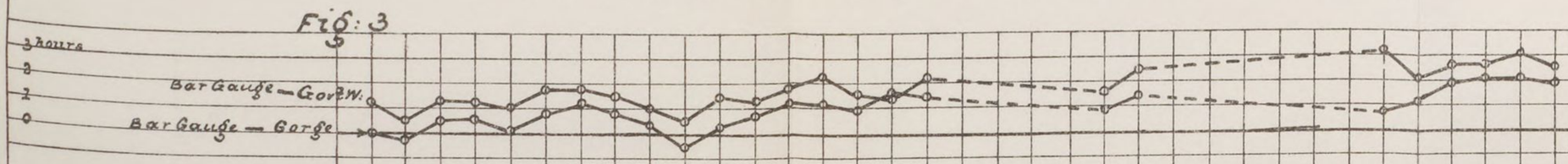
MONTHLY FLUCTUATION OF MEAN LOW TIDE FROM JUNE 1/94 TO JUNE 1/96
as observed at Gov't: Wharf

Fig: 2



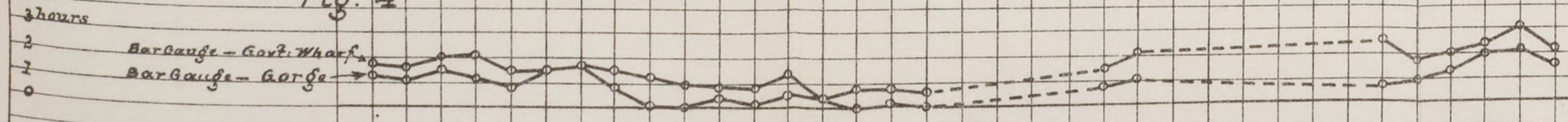
RETARDATION CURVES HIGH WATER

Fig: 3



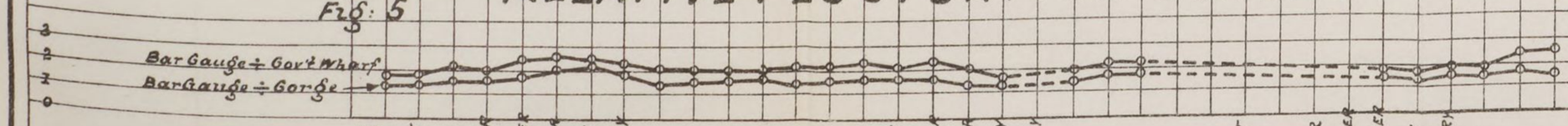
RETARDATION CURVES LOW WATER

Fig: 4



RELATIVE FLUCTUATION CURVES

Fig: 5



RESPECTFULLY SUBMITTED TO Major A.M. Miller with my Report of JUNE 30/96

W. P. Judson
1st Lieut: Corps of Eng: U.S.A.

ANDREW B. GRAHAM, PHOTO-LITHO. WASHINGTON, D.C.

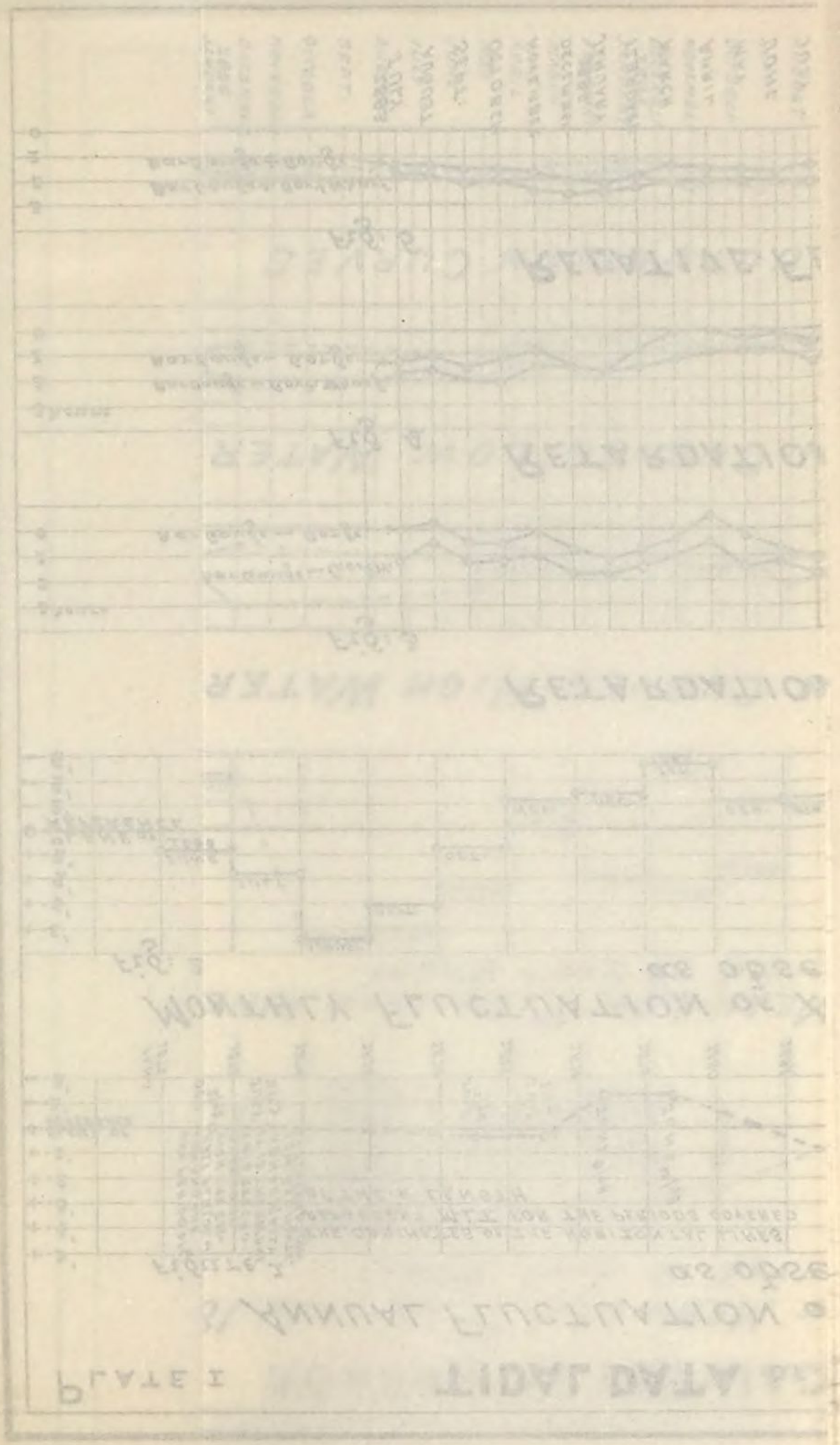
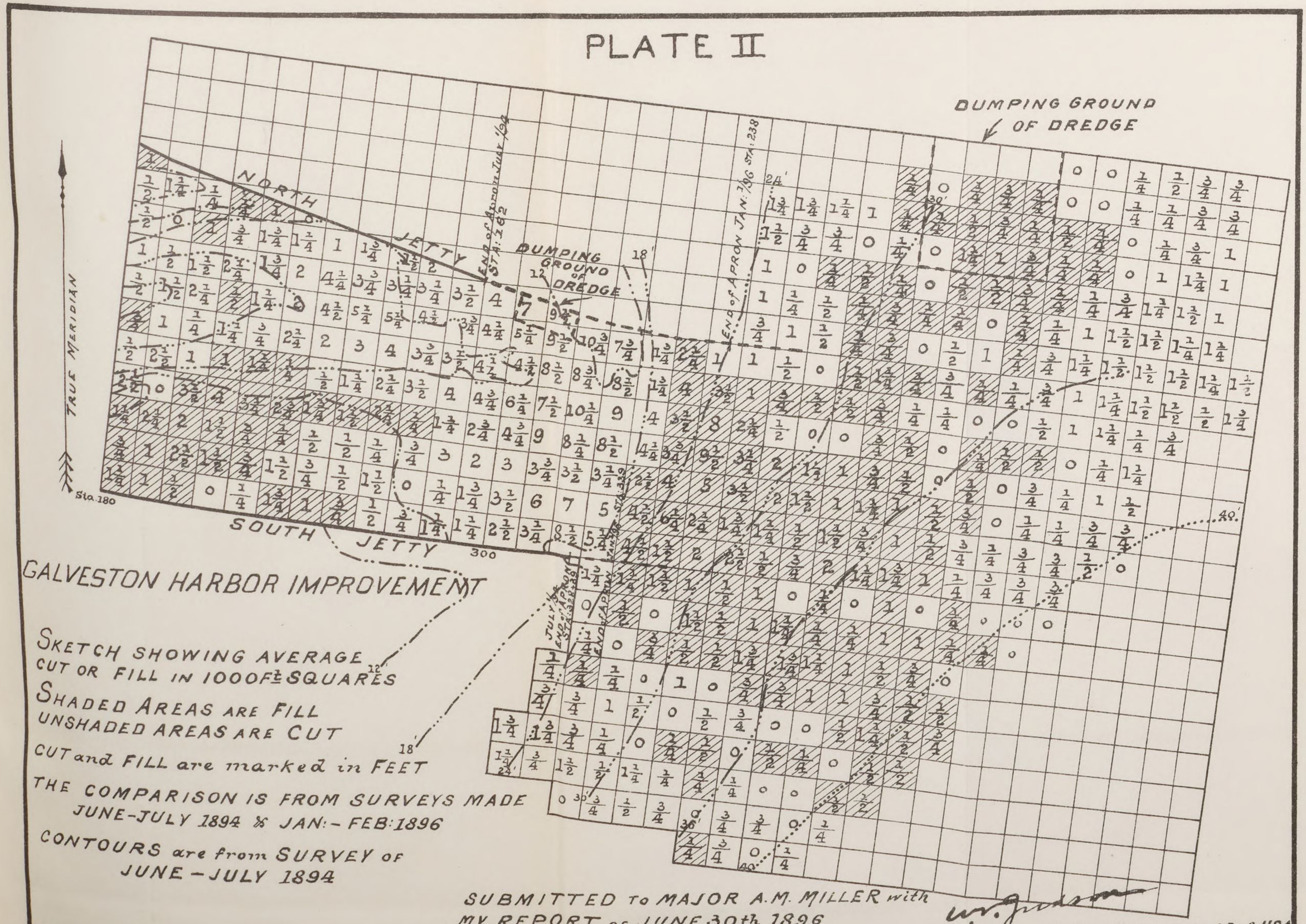


PLATE II



GALVESTON HARBOR IMPROVEMENT

SKETCH SHOWING AVERAGE CUT OR FILL IN 1000 Ft SQUARES

SHADED AREAS ARE FILL
UNSHADED AREAS ARE CUT

CUT and FILL are marked in FEET

THE COMPARISON IS FROM SURVEYS MADE JUNE-JULY 1894 & JAN:- FEB: 1896

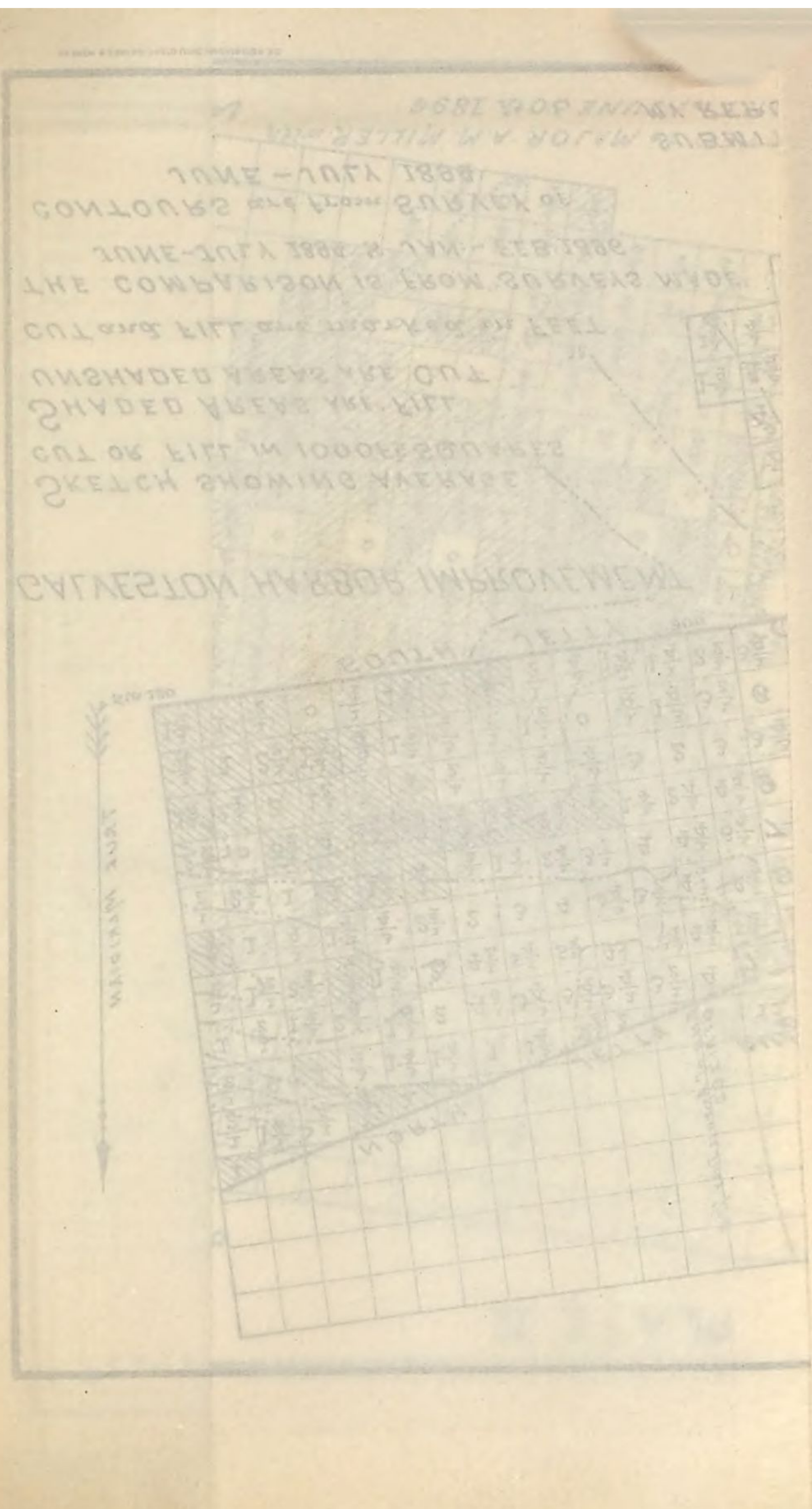
CONTOURS are from SURVEY of JUNE - JULY 1894

SUBMITTED to MAJOR A.M. MILLER with MY REPORT of JUNE 30th 1896

W. Graham

1st Lieut: Corps of Eng: USA

ANDREW B. GRAHAM, PHOTO-LITHO WASHINGTON, D.C.



The navigable depth over the outer bar in 1887 was 12¾ feet; in 1896, 22 feet; inner bar in 1887, 20½ feet; in 1896, 24 feet. A gain to the port of 9¼ feet on the outer bar and 3½ on the inner.

Very respectfully, your obedient servant,

E. M. HARTRICK,
Assistant Engineer.

First Lieut. WM. V. JUDSON,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS OF GALVESTON HARBOR, TEXAS, FOR FISCAL YEAR ENDING JUNE 30, 1896.

Tonnage of vessels and revenue collected.

	Steam vessels.	Sailing vessels.	Total.	Total tonnage.
Entered	335	128	463	607,074
Cleared	335	107	442	614,680
Total	670	235	905	1,221,754

Duties on imports collected $146,466.62

Amount and value of freight transported.

Articles.	Tons.	Approximate value.
Cotton (956,110 bales)	249,227	$39,388,000
Cotton products	112,350	2,147,000
Ore	1,514	168,600
Wool	6,031	808,600
Grain	127,602	1,482,600
Sugar	3,207	229,600
Coal	141,230	377,900
General merchandise	131,435	1,888,500
Total	772,596	46,490,800

Decrease of freight carried compared with last year, 53,529 tons. This is almost entirely due to the short cotton crop; the receipts at Galveston were 653,428 bales less than last year.

Comparative statement for fiscal years 1894 to 1896.

Articles.	1894.	1895.	1896.
Cotton ..... tons	239,183	402,385	249,227
Cotton products ..... do	80,474	125,172	112,350
Ore ..... do	531	1,000	1,514
Wool ..... do	5,542	7,337	6,031
Grain ..... do	10,949	1,317	127,602
Sugar ..... do	.....	.....	3,207
Coal ..... do	180,000	288,914	141,230
General merchandise ..... do	.....	.....	131,435
Total tonnage	516,679	826,125	772,596
Total value	$44,003,000	$56,951,000	$46,490,800

Comparative tables of freight rates.

[Compressed cotton per 100 pounds.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892	60	60	60	60	60	60	60	60	60	45	44	40
1893	39	42	42	42	42	42	42	42	42	52	55	55
1894	55	52	52	52	52	52	52	52	44	52	56	45
1895	52	45	42	42	42	42	42	42	42	32	32	45

Comparative tables of freight rates—Continued.

Year.	Oil cake per 100 pounds.	Grain per quarter.
1894	22.5	.....
1895	19.7	79

Proportion of cargo lightered to total freight carried.

	Per cent.
1893	13
1894	9
1895	*5

S 2.

IMPROVEMENT OF SHIP CHANNEL IN GALVESTON BAY, TEXAS.

The dredging of a channel through Galveston Bay was undertaken with a view to affording an outlet to the Gulf for the commerce using the bayous and rivers (principally Buffalo Bayou) emptying into the bay at its northern extremity. The natural depth along the line of the proposed channel was from 7 to 8½ feet, which was not sufficient for the demands of navigation, at least 12 feet of water being required.

A channel 0.63 mile long had been constructed across Morgans Point, at the mouth of the San Jacinto River, by the Buffalo Bayou Ship Channel Company, who had also dredged a channel 4.8 miles long, extending out into the bay from the southern extremity and in continuation of the line of the canal. This canal and cut were known as "Morgans Cut and Canal."

The project adopted in 1871 and modified in 1877 consisted in dredging and maintaining a channel at least 100 feet wide at the bottom and 12 feet deep, so as to connect the "Morgans Canal and Cut" with Bolivar Channel, a distance of 18.9 miles. In 1881 the Buffalo Bayou Ship Channel Company agreed to surrender to the United States their work at Morgans Point, together with their charter and rights under it, upon the completion by the Government of the ship channel in Galveston Bay.

The dredging of this channel was commenced in 1872 and was carried on at intervals as funds were available until July 20, 1889, when it was completed to the desired width and depth.

Upon its completion the Buffalo Bayou Ship Channel Company was called upon to transfer to the United States the "Morgans Canal and Cut" in accordance with the agreement entered into by them on February 14, 1881.

This transfer was finally accomplished on May 4, 1892, and a modified project was then adopted which contemplated the dredging and maintaining of a channel, at least 100 feet wide at the bottom and 12 feet deep, from Bolivar Channel to the upper end of Morgans Canal, a distance of 24.33 miles, the channel to be marked by beacons. The estimated cost of this improvement, as revised in 1892, was $896,175.44.

Owing to the fact that no dredging was done from July 20, 1889, up to the present time in the section of the channel between Bolivar Channel and Morgans Cut, a gradual shoaling has taken place, due to the

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* All lighterage in 1895 was done during the first six months.

action of winds and tides, so that there is now a depth of only about 8½ feet available for vessels between those points.

Upon the resumption of work in 1893, the revetment work of Morgans Canal was first repaired, then the widening and deepening of Morgans Cut was undertaken.

At the close of the last fiscal year this portion of the ship channel had been widened to 150 feet and deepened to 9½ feet, besides which it had been partially deepened to 12 feet along its center for a width of 40 feet.

This deepening along the center of the cut to 12 feet was in progress at the beginning of this fiscal year, the idea being to make this portion of the channel 75 feet wide.

The work was carried on under a contract entered into December 8, 1894, and approved December 17, 1894, with Chas. Clarke & Co., of Galveston, Tex., by the terms of which dredging was to be commenced on or before January 1, 1895, and was to be completed by September 30, 1895.

Dredging was continued under this contract during the present fiscal year until it was completed on September 26, 1895. The amount of material removed from July 1 to September 26, 1895, was 122,513 cubic yards.

In addition to the dredging ten beacons were rebuilt during the year.

The Morgan Cut now has a width of 150 feet and a depth of 9½ feet at mean low tide, along the center of which the depth is 12 feet at mean low tide for a width of 75 feet.

The amount of material removed from the cut and the cost of dredging is as follows:

Contract of Rittenhouse Moore Dredging Company, 228,961 cubic yards, at 24½ cents.
Contract of Chas. Clarke & Co., 346,260 cubic yards, at 12½ cents.

It is not practicable to give the statistics of the commerce of the ship channel. Almost the entire floating commerce of Buffalo Bayou, Trinity River, and Cedar Bayou is carried through this channel, the commercial statistics being given in the reports on those works. The number of vessels passing through Morgans Canal during the year was 1,805, of which 966 were north bound and 839 were south bound.

It is believed by many of the best-informed business men of Houston that the advantages to be derived from enabling seagoing ships to reach Houston by way of the ship channel and Buffalo Bayou will be vastly greater than the cost of making and maintaining it.

In this connection attention is respectfully called to the recommendations contained in report on the improvement of Buffalo Bayou, Texas, favoring the consolidation of the two works and the purchase of a modern dredging plant for carrying on operations.

Amount expended on this improvement to June 30, 1895	$649,506.86
Amount expended during present fiscal year	26,813.14
Total amount expended to June 30, 1896	676,320.00

Abstract of appropriations made by Congress for improving ship channel in Galveston Bay, Texas.

By act of—		By act of—	
March 3, 1875	$25,000	August 11, 1888	$100,000
August 4, 1876	72,000	September 19, 1890	40,000
June 18, 1878	75,000	July 13, 1892	40,000
March 3, 1879	80,000	August 17, 1894	50,000
June 14, 1880	50,000	June 3, 1896	50,000
March 3, 1881	50,000		
August 2, 1882	94,500	Total	726,500

Money statement.

July 1, 1895, balance unexpended	$26,993.14
Amount appropriated by act of June 3, 1896	50,000.00
	76,993.14
June 30, 1896, amount expended during fiscal year	26,813.14
July 1, 1896, balance unexpended	50,180.00
July 1, 1896, outstanding liabilities	45.00
July 1, 1896, balance available	50,135.00
Amount (estimated) required for completion of existing project	169,675.44
Amount that can be profitably expended in fiscal year ending June 30, 1898	169,675.44
Summitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

S 3.

IMPROVEMENT OF CHANNEL IN WEST GALVESTON BAY, TEXAS.

West Galveston Bay is an expanse of water between Galveston Island and the mainland and extends from Galveston Bay to the west end of Oyster Bay. It is connected with the Gulf of Mexico by San Luis Pass, at the western extremity of Galveston Island, in which the depth is from 7 to 8 feet, and with Brazos River by the Galveston and and Brazos Canal, in which the depth was originally dredged to 7 feet, but has since shoaled to 4 feet. The natural channel through the bay was crooked and narrow, the depth varying from 2½ to 5 feet.

Prior to the improvement of this locality by the United States a channel having a depth of 5 feet was dredged through the bay by the State of Texas in 1859; it had, however, shoaled to its original depth before the present work was commenced.

The project adopted for this improvement consisted in widening and straightening the channel to 200 feet and in deepening it to 3½ feet, between Galveston Bay and San Luis Pass; also in dredging a channel 100 feet wide and 3 feet deep along Christmas Point, in Oyster Bay. Beacons were also to be erected along the line of the channel so as to properly define it.

Dredging was commenced on the proposed channel on January 19, 1893, and at the close of the last fiscal year a cut 100 feet wide and 3½ feet deep had been completed across Deer Islands and Karonkaway Reefs.

At the beginning of the present fiscal year dredging was in progress under a contract entered into with Charles Clarke & Co., of Galveston, Tex., on December 8, 1894, work to be commenced on or before January 1, 1895, and to be completed by November 30, 1895. This contract was completed on October 2, 1895. Work during the fiscal year consisted in dredging a channel 100 feet wide and 3 feet deep along Christmas Point, in Oyster Bay, the amount of material removed having been 6,333 cubic yards.

At the close of the season's work on October 2, 1895, an unobstructed channel, 100 feet wide and from 3 to 3½ feet deep at mean low tide, had been secured through the bay from Galveston Bay to the Galveston and Brazos Canal. The necessary beacons to define the channel had also been erected.

The amount of material dredged since this work was commenced and the cost of the dredging is as follows:

Contract of Branch T. Masterson, 13,963 cubic yards at 30 cents.
Contract of Charles Clarke & Co., 14,264.73 cubic yards at 60 cents.

The progress on this work has been slow and the cost of dredging correspondingly high, owing to its character, the average depth of excavation required being less than 1 foot.

Amount expended on this improvement to June 30, 1895	$13,408.86
Amount expended during present fiscal year	6,342.11
Total amount expended to June 30, 1896	19,750.97

Abstract of appropriations made by Congress for improving channel in West Galveston Bay, Texas.

By act of—	
July 13, 1892	$15,000
August 17, 1894	5,000
June 3, 1896	5,000
Total	25,000

Money statement.

July 1, 1895, balance unexpended	$6,591.14
Amount appropriated by act of June 3, 1896	5,000.00
	11,591.14
June 30, 1896, amount expended during fiscal year	6,342.11
July 1, 1896, balance unexpended	5,249.03
Amount (estimated) required for completion of existing project	4,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	4,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS OF WEST GALVESTON BAY, TEXAS, FOR THE FISCAL YEAR ENDING JUNE 30, 1896.

Vessels using bay, 26 (1 steamer, 5 barges, and 20 sailing vessels); length, 20 to 140 feet; draft, 3 to 5 feet; tonnage, 3 to 240 tons.

Amount and value of freight transported.

Articles.	Tons.	Approximate value.
Cotton	1,875	$225,000
General merchandise	4,500	217,500
Total	6,375	442,500

Decrease since last year, 2,125 tons.

Comparative statement for fiscal years 1894 to 1896.

Articles.	1894.	1895.	1896.
Cotton ..... tons..	6,500	2,500	1,875
General merchandise ..... do...	3,510	6,000	4,500
Total tonnage	10,010	8,500	6,375
Total value	$711,500	$590,000	$442,500

S 4.

IMPROVEMENT OF TRINITY RIVER, TEXAS.

Trinity River empties into Galveston Bay near its northeast extremity through several mouths or passes, the relative importance of which appears to have varied considerably. The one generally used by vessels of late years has been the Middle Pass, in which the depth of water is 9 feet or more; in the river above there is 16 feet of water. Opposite each of the mouths a bar has been formed by the action of the tides and winds. The depth on the bar opposite the Middle Pass was 3½ feet, which was not sufficient for vessels entering the river, a depth of from 5½ to 6 feet being required.

A project was adopted in 1873 and subsequently revised in 1889, the object being to increase the depth on the bar opposite the Middle Pass to 6 feet by the erection of two parallel jetties placed about 275 feet apart and extending 7,750 feet into Galveston Bay; also in closing the other passes by submerged dams, so as to concentrate the discharge of the river as much as possible through one outlet.

Previous to the adoption of this project a channel had been dredged and redredged across the bar and 4,575 feet of jetties had been constructed. Owing to the irregularity with which work was carried on, due to lack of appropriations and natural causes, this channel became almost obliterated, and of the revetment but 2,100 feet remained in good condition.

Upon resumption of work in 1889, the extension of the west jetty was commenced and continued, when funds were available, until completed April 6, 1894, its length being then 7,359 feet.

A channel 100 feet wide and 5 feet deep at mean low tide was also dredged across the bar in April, 1894, in order to afford some immediate relief to navigation.

The condition of the improvement remained the same at the close of the last fiscal year as on June 30, 1894, except possibly a slight shoaling in the channel dredged across the bar, the construction of the east jetty having been postponed until sufficient funds were available to warrant commencing the work.

No work was carried on during the present fiscal year, it having been recommended and approved that the construction of the east jetty be postponed until another appropriation had been made for this work, as the small balance ($2,700) available for the work could not be expended economically.

A special agent was employed during the year to keep a record of the commerce and tonnage of the river.

Amount expended on this improvement to June 30, 1895	$68,917.26
Amount expended during present fiscal year	262.50
Total expended to June 30, 1896	69,179.76

Abstract of appropriations made by Congress for improving Trinity River, Texas.

By act of—		By act of—	
June 18, 1878	$10,000	September 19, 1890	$10,000
March 3, 1879	2,500	July 13, 1892	10,000
June 14, 1880	4,000	August 17, 1894	5,000
March 3, 1881	10,000	June 3, 1896	5,000
August 2, 1882	8,000		
August 11, 1888	12,500	Total	77,000

Money statement.

July 1, 1895, balance unexpended	$3,082.74
Amount appropriated by act of June 3, 1896	5,000.00
	8,082.74
June 30, 1896, amount expended during fiscal year	262.50
July 1, 1896, balance unexpended	7,820.24
July 1, 1896, outstanding liabilities	30.00
July 1, 1896, balance available	7,790.24
Amount (estimated) required for completion of existing project	15,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	15,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS OF TRINITY RIVER, TEXAS, FOR THE FISCAL YEAR ENDING JUNE 30, 1896.

Vessels using the river, 26 (24 sailing vessels, 1 barge, and one steamer); length on deck, 30 to 150 feet; draft, 2.5 to 5 feet; tonnage, 4 to 100 tons; trips made during the year, 915; total tonnage, 11,385.

Amount and value of freight transported.

Articles.	Tons.	Approximate value.
Cotton	27	$4,348
Lumber	6,955	18,665
Coal	602	8,128
Stock	64	3,533
General merchandise	73	3,172
Total	7,721	37,846

Decrease since last year, 2,137 tons.

Comparative statement for fiscal years 1894 to 1896.

Articles.	1894.	1895.	1896.
Cotton ..... tons	214	79	27
Lumber ..... do	7,050	8,747	6,955
Coal ..... do	241	385	602
Stock ..... do	7	86	64
General merchandise ..... do	170	561	73
Total tonnage	7,682	9,858	7,721
Total value	$68,272	$56,497	$37,846

S 5.

IMPROVEMENT OF BUFFALO BAYOU, TEXAS.

Buffalo Bayou is a tide-water stream emptying into the San Jacinto River at Lynchburg, about 25 miles below Houston and about 8 miles above the mouth of the river. White Oak and Simms bayous are tributaries, the former entering at Houston and the latter at a point about 11 miles below.

In its natural state, the bayou between Houston and Simms Bayou was narrow and tortuous and the channel obstructed by shoals, logs, and overhanging trees; below Simms Bayou it was wide and deep.

A survey of the stream was made in 1871, and again in 1880, in order to devise a project for its improvement. The plan adopted consisted in widening and deepening the channel so that it should have the same dimensions as that contemplated for Galveston Bay, namely a width of at least 100 feet and depth of 12 feet; also to remove such snags, logs, and overhanging trees as obstructed navigation. The estimated cost of the work was $385,299.75, and it was expected that when completed seagoing vessels would be able to reach Houston.

Work on this improvement commenced February, 1882, and has been carried on whenever funds were available. At different times the channel was widened and deepened to 10 feet and all obstructions were removed; the benefit secured, however, was only temporary, as while work was suspended for lack of funds a shoaling occurred on the bars due to surface wash from the banks and sewage from the city of Houston, and a new supply of snags and logs was brought down the bayou after the heavy rains, which generally lodged in the channel.

At the close of the last fiscal year a depth of 8 feet was available for vessels from Houston to the mouth.

At the beginning of the present year work was in progress under a contract entered into on December 18, 1894, and approved January 4, 1895, with the Rittenhouse Moore Dredging Company, of Mobile, Ala., work to commence on or before March 1, 1895, and to be completed by November 30, 1895. This contract was completed on November 4, 1895, the following amount of work having been accomplished since July 1, 1895:

36,474 cubic yards of material dredged, at a cost of 30 cents per cubic yard.
747 cubic feet of logs removed, at a cost of 6 cents per cubic foot.
20,500 cubic feet of trees felled, at a cost of 5 cents per cubic foot.
32 stumps removed, at a cost of $23.85 each.

At the close of the season's work the channel had a depth of 10 feet and was clear of obstructions.

The details of the work are shown in the report of Mr. R. B. Talfor, assistant engineer, which is forwarded herewith and to which attention is invited.

Buffalo Bayou is one link in a waterway designed to connect Houston with Galveston and the Gulf of Mexico, the other links being the San Jacinto River, the Morgan Canal, and the ship channel in Galveston Bay.

The improvements on Buffalo Bayou and in Galveston Bay are carried on under separate appropriations, and, unless work is advanced as rapidly at one locality as at the other, it is impossible to secure a uniform depth for navigation over the whole distance.

In Buffalo Bayou the depth is generally less than that in Galveston Bay, consequently vessels that could otherwise reach Houston are prevented from going there.

To remedy this it would seem to be more beneficial if both works were consolidated into one, so that whatever appropriations were made might be expended at such points in the entire distance to Houston as would enable a channel of a uniform width and depth to be maintained. It is therefore recommended that in making future appropriations for Buffalo Bayou and the ship channel in Galveston Bay both works be consolidated into one, having the title "Improvement of waterway between Houston and Galveston, Tex."

It is also recommended that the improvement commence at the head of Long Reach in Buffalo Bayou, a point about 6½ miles below Main street in Houston. The reason for this recommendation is that surface

wash and the sewerage from Houston causes rapid shoaling in the portion of the bayou above Long Reach, thereby greatly increasing the cost of the improvement; below the head of Long Reach it will be comparatively easy to obtain and maintain a 12-foot channel. Commerce should be required to adjust itself to these new conditions which would obviate the maintenace of a very narrow, tortuous, and shoal channel into the heart of Houston.

For carrying on the work in Buffalo Bayou and Galveston Bay a modern dredging plant should be purchased at an estimated cost of $200,000. This would effect a great saving over work done by contract, as in a few years the dredge would have paid for itself besides having done an amount of work equal to what could have been done at previous contract prices.

The commerce carried between Houston and Galveston by water is considerable. Large shipments of cotton and cotton-seed products are made on barges, towed by tugs, to be loaded on seagoing vessels at the latter place. During the last two years the number of bales shipped in this manner amounted to 828,766. To ascertain the extent of the trade on the bayou a special agent was employed at Houston to keep a daily record of the tonnage and commerce.

Amount expended to include June 30, 1895	$194,641.78
Amount expended during present fiscal year	13,677.04
Total amount expended to June 30, 1896	208,318.82

Abstract of appropriations made by Congress for improving Buffalo Bayou, Texas.

By act of—		By act of—	
March 3, 1881	$25,000	July 13, 1892	$25,000
August 2, 1882	50,000	August 17, 1894	15,000
July 2, 1884	25,000	June 3, 1896	20,000
August 5, 1886	18,750		
August 11, 1888	25,000	Total	228,750
September 19, 1890	25,000		

Money statement.

July 1, 1895, balance unexpended	$14,108.22
Amount appropriated by act of June 3, 1896	20,000.00
	34,108.22
June 30, 1896, amount expended during fiscal year	13,677.04
July 1, 1896, balance unexpended	20,431.18
July 1, 1896, outstanding liabilities	45.00
July 1, 1896, balance available	20,386.18
Amount (estimated) required for completion of existing project	156,549.75
Amount that can be profitably expended in fiscal year ending June 30, 1898	100,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

REPORT OF MR. R. B. TALFOR, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., June 30, 1896.

MAJOR: I have the honor to make the following report relative to the improvement of Buffalo Bayou, Texas, for the fiscal year ending June 30, 1896:

Owing to the small appropriation ($15,000) to improve this valuable waterway, over which was carried during the season of 1894–95 more than 570,000 bales of cotton

alone, the work of improvement was confined to the removal of the shoalest places by dredging to a depth of 10 feet, also to removing such stumps, sunken logs, and overhanging trees as were in the way of navigation.

The largest amount of work done was within the city limits of Houston, from the foot of Main street to the City Mills, where most of the cotton presses are situated and the shoalest water is found, with the exception of two shoals near the San Antonio and Aransas Pass Railway Bridge and at Harrisburg Bend.

These two shoals are formed by the earth carried into the bayou through the ravines or gullies which carry the wash from the cultivated or broken ground during heavy rains. There are a number of places on the bayou that shoal from the same cause.

Another and a very large cause of shoaling is the very bad condition of the bulkhead between the mouth of White Oak Bayou and the San Jacinto Street Bridge in the city of Houston, which is neither water nor earth tight, and too loose to prevent any of the material carried in suspension by the water from the drains and gullies of the city from being carried into the bayou and deposited in front of the so-called wharves. The gutters, instead of being swept, are flushed, and their contents are all carried into the bayou instead of being otherwise disposed of. The attention of the city officials has been frequently called to this fact, but without any beneficial results. It is to be hoped that the present board of city officials will take steps to remedy this evil, as making a dumping ground of the bayou, together with the present system of sewerage, all of which is discharged into the bayou (causing additional shoaling), will in the near future prove a serious detriment to the navigation of this valuable waterway, besides menacing the health of the city, specially during the summer months and small rainfall, which leaves the bayou in a very polluted condition for several miles down stream from Houston. This filthy condition obtains until the bayou is flushed by heavy rains. In the report of the Chief of Engineers for 1891, part 3, page 1928, reference is made to a report of Mr. Chas. W. Lewis, city engineer, at the time, in which he gives the number, location, and size of sewers emptying into the bayou, viz:

"Thirty-nine by fifty-one-inch brick combined sewer emptying into bayou at foot of Congress street. This sewer is intended to drain surface water besides sewage, and covers an area of about 100 acres, with 5 miles of pipe laid.

"Twenty-four-inch vitrified clay pipe emptying into bayou at foot of La Branch street, for house sewage only, and covers an area of about 250 acres, with 12 miles of pipe laid.

"Four by five and one-half foot brick drain, emptying into bayou at foot of Caroline street. This is a combined sewer drainage of about 100 acres, with $2\frac{3}{4}$ miles of pipe laid.

"There is comparatively a small number of house connections made with these sewers, and the volume of sewage at present is limited.

"The city of Houston intends as soon as the demand requires to lay a large pipe or conduit to take the sewage from the various sewers and discharge at some point about $2\frac{1}{2}$ miles north of the center of the city.

"Besides the sewers enumerated as above it is contemplated to lay sanitary sewers throughout the entire city as soon as the population requires the same.

"There are also two private lines of sewers discharging into the bayou at the foot of Fannin street and Prairie street, respectively. These two sewers drain a very small area and will ultimately be connected with the public sewers."

Time of beginning, also location and amount of work done.—Although the time of beginning the work according to the specification was set March 1, 1895, it was not until August 1, 1895, that active operations were begun, which ceased for lack of funds on November 4, 1895. In the interim, March to August, the contractor not having a suitable plant for this particular kind of work, notably a boom derrick to carry the material excavated onto and behind the crest of the high banks, tried various appliances to hoist and swing the spoil on the banks, the result being only 150 cubic yards excavated at the foot of Main street. The time for completing the contract having expired, an extension was granted and another plant furnished and the work carried forward with few delays till November 4, 1895, when the available funds were exhausted.

The following shows amount of work done:

Material dredged	cubic yards..	36,474
Logs removed	cubic feet..	747
Overhanging trees removed	do....	20,500
Time expended removing stumps	hours..	$56\frac{1}{2}$

R. B. TALFOR,
Assistant Engineer.

Maj. A. M. MILLER,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS OF BUFFALO BAYOU, TEXAS, FOR THE FISCAL YEAR ENDING JUNE 30, 1896.

Vessels using bayou, 88 (10 steam vessels, 29 barges, and 49 sailing vessels); length, 24 to 162 feet; draft, 2 to 6.5 feet; tonnage, 2.5 to 358 tons; trips made during the year, 2,652; total tonnage, 307,003.

Amount and value of freight transported.

Articles.	Tons.	Approximate value.
Cotton (314,745 bales)	78,686	$14,151,127
Cotton products	16,672	250,075
Coal	1,660	8,300
Lumber	3,185	82,485
Building material	5,485	9,350
General merchandise	9,191	66,035
Total	114,879	14,567,392

Decrease since last year, 45,589 tons, largely due to short cotton crop, 199,276 less bales having been transported down the bayou.

Comparative statement for fiscal years 1894 to 1896.

Articles.	1894.	1895.	1896.
Cotton ....tons..	69,029	128,506	78,686
Cotton products ....do...	7,737	12,595	16,672
Coal ....do...	7,867	4,758	1,660
Sugar ....do...	3,277	.....	.....
Lumber ....do...	839	4,440	3,185
Building material ....do...	14,508	7,028	5,485
General merchandise ....do...	4,808	3,141	9,191
Total tonnage	108,065	160,468	114,879
Total value	$12,262,667	$16,243,796	$14,567,372

S 6.

SURVEY OF TRINITY RIVER, TEXAS, FROM MAGNOLIA TO DALLAS.

[Printed in House Doc. No. 102, Fifty-fourth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 18, 1895.

SIR: The river and harbor act of August 17, 1894, in the item making an appropriation for improving Trinity River, Texas, provides for a survey from Magnolia to the city of Dallas. This survey, embracing a length of 206¾ miles, was begun in October, 1894, and the field work was completed January 12, 1895, and I have now the honor to submit the accompanying copy of report, dated November 4, 1895, by Maj. A. M. Miller, Corps of Engineers, of the results.

In addition to the natural obstructions, which consist of shoals, snags, and drift piles or rafts, there are 14 bridges crossing the river between Dallas and Magnolia, which, with the exception of 2, are without drawspans and vary in height above low water from 33 feet to 53 feet, and unless altered would prevent navigation by any but very small boats at any ordinary boating stage.

By clearing this portion of the river from overhanging trees, snags, and drift piles a precarious navigation for four months in the year would

be obtained with a depth of water of from 4 feet to 6 feet. It is estimated that this would cost about $600 per mile, or about $125,000.

To obtain slack-water navigation between Dallas and Magnolia will require the construction of 16 locks, which at $100,000 per lock and dam will cost $1,600,000.

Major Miller in closing his report states that—

> The present condition of the Trinity River below Magnolia is such that the improvement of the portion between Dallas and Magnolia would give no outlet to the products of the country bordering the stream, and any local traffic that would be benefited would be so small that, in my opinion, this portion of the river is not at present worthy of improvement by the United States.

In forwarding Major Miller's report to this office Col. Henry M. Robert, Corps of Engineers, Division Engineer, uses the following language:

> The magnitude of the interests involved, as stated in the papers inclosed, would seem to justify the improvement of the Trinity River in the future, provided that the expenditure of a reasonable sum would insure navigation from Dallas to Galveston. But it is useless to undertake the improvement of the river above Magnolia at an expense of $1,600,000 when Congress has shown itself unwilling to give more than about $5,000 a year toward improving the channel across the bar at the mouth of this river. There is nothing that would justify the improvement of this upper part of the river independently of its mouth. No improvement is justifiable unless the route from Dallas to Galveston is considered as a whole. And even then I doubt whether it should be undertaken until Congress is prepared to appropriate upon the basis of completing the work within twenty years.

Very respectfully, your obedient servant,

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

Hon. DANIEL S. LAMONT,
Secretary of War.

REPORT OF MAJ. A. M. MILLER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., November 4, 1895.

GENERAL: In compliance with instructions contained in letter dated Office Chief of Engineers, United States Army, October 31, 1895, I have the honor to report as follows on a survey of the Trinity River, Texas, from Magnolia to Dallas, Tex.

The survey of the Trinity River, Texas, from Magnolia to Dallas was begun October 22, 1894, and the field work was completed January 12, 1895.

The general course of the river from Dallas to Magnolia is southeast, the length being 206¾ miles. The river flows through Dallas County and forms the boundary between Ellis and Kaufman, Navarro and Henderson, and Freestone and Anderson counties.

At the time of the survey the water was very low, so low that much time was lost in making portages around and hauling the skiffs over the shoals and rafts which constitute the principal obstructions in the stream. About 14½ miles below Dallas the Trinity River Navigation Company has constructed a dam, with a view to slack-water navigation, which at present is a complete obstruction to navigation at low water. The difference between high and low water is from 25 to 30 feet; the banks vary in height from 30 to 16 feet, so that the "bottom" through which the stream flows is subject to overflow; this bottom is heavily timbered and varies from 3 to 7 miles in width.

The river has a fall at low water between Dallas and Magnolia of 189 feet in 206¾ miles.

The products of the country are cotton, corn, wheat, oats, and lumber.

In addition to the natural obstructions, which consist of shoals, snags, and drift piles, or rafts, there are 14 bridges crossing the stream between Dallas and Magnolia, which, with the exception of 2, are without draw-spans and vary in height, above low water, from 33 to 53 feet, and unless altered would prevent the navigation of the river by any but very small boats at any ordinary boating stage.

By clearing this portion of the river from overhanging trees, snags, and drift piles a precarious navigation for four months in the year would be obtained, with a depth of water of from 4 to 6 feet.

It is estimated that this would cost about $600 per mile, or about $125,000.

To obtain slack-water navigation between Dallas and Magnolia by means of locks and dams there would be required 16 locks with 12-foot lifts, which, at $100,000 per lock and dam, would amount to $1,600,000; this estimate is not high.

The present condition of the Trinity River, below Magnolia, is such that the improvement of the portion between Dallas and Magnolia would give no outlet to the products of the country bordering the stream, and any local traffic that would be benefited would be so small that, in my opinion, this portion of the river is not at present worthy of improvement by the United States.

The details of the survey are shown in the report of Mr. F. Oppikofer, assistant engineer, which is forwarded herewith and to which attention is invited.

A statement of the commercial statistics of the country tributary to this portion of the river, prepared by Messrs. Duncan and Griffiths, is also forwarded herewith, as well as a set of tracings* (13 sheets) of the survey.

Very respectfully, your obedient servant,

A. M. MILLER,
Major, Corps of Engineers.

Brig. Gen. WM. P. CRAIGHILL,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, SOUTHWEST DIVISION,
New York, December 14, 1895.

Respectfully forwarded to the Chief of Engineers, United States Army. The magnitude of the interests involved, as stated in the papers inclosed, would seem to justify the improvement of the Trinity River in the future, provided that the expenditure of a reasonable sum would insure navigation from Dallas to Galveston. But it is useless to undertake the improvement of the river above Magnolia at an expense of $1,600,000 when Congress has shown itself unwilling to give more than about $5,000 a year toward improving the channel across the bar at the mouth of this river. There is nothing that would justify the improvement of this upper part of the river independently of its mouth. No improvement is justifiable unless the route from Dallas to Galveston is

* Not printed.

considered as a whole. And even then I doubt whether it should be undertaken until Congress is prepared to appropriate upon the basis of completing the work within twenty years.

I therefore concur in the opinion of Major Miller, that the Trinity River, Texas, between Dallas and Magnolia, is not at present worthy of improvement.

HENRY M. ROBERT,
Colonel of Engineers, Division Engineer.

REPORT OF MR. F. OPPIKOFER, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., July 1, 1895.

MAJOR: I have the honor to submit the following report upon the survey of the Trinity River, from Dallas to Magnolia, Tex.

In accordance with your instructions of November 12, 1894, I joined the Trinity River survey party, already organized and in the field, 10 miles below Dallas, November 15, 1894.

The survey was made under the most favorable conditions, the river being at an extremely low state and all obstructions in plain view.

The field work was finished January 12, 1895. Considerable time was lost in portage of our outfit over drifts and shoals.

A continuous transit and level line was carried the entire distance (206¾ miles) to Magnolia. The zero of the line was taken at the Texas Pacific Railroad Bridge, at the foot of Main street, Dallas, Tex., with an elevation at the top of rail of 430 inches above mean low tide in Gulf.

Distance was measured with the stadia, which was checked on a base line at intervals.

Soundings were carefully taken at every station, the average distance being 778 feet. Between stations the depths were examined by continuous soundings.

Bench marks were established wherever practicable, and are shown on the map.*

Cross sections were taken from 1 to 2 miles apart and all shoals developed.

Fourteen bridges in all were found between Dallas and Magnolia. They are in the following order:

Name of bridge.	Span.	Extreme low water to lower chord.	Piers.	Clearance between piers.	Remarks.
		Feet.		*Feet.*	
Texas Pacific R. R.....	Iron span, 158 feet...	52	Wood, stone foundation.	150	Foot of Main street, Dallas, Tex.
Dallas and Oak Cliff Street Rwy.	Iron span, 151.5 feet.	48.5	Cylinder iron.	142	Between Main and Commerce streets, Dallas.
Commerce Street Wagon Bridge.	Iron span, 160.5 feet and 140.5 feet.	49	Stone.....	145	Foot of Commerce street.
Dallas and Oak Cliff Street Rwy.	Iron span, 177.5 feet.	39.5	Cylinder iron.	172	1 mile from Dallas.
Oak Cliff Wagon Bridge.	Iron span, 158.7 feet.	39.5	.....do.....	152	1⅓ miles from Dallas.
Gulf, Colorado and Santa Fe R. R.	Iron span, 200.5 feet.	41	Stone.....	190	3¼ miles from Dallas.
Missouri, Kansas and Texas R. R.	Iron span, 202 feet...	36	Wood.....	165	4 miles from Dallas.
Millers Ferry Bridge..	Iron span, 158.7 feet.	42	Cylinder iron.	150	6⅓ miles from Dallas.
Houston and Texas Central R. R.	Iron span, 129.8 feet.	38.5	Brick.....	115	6¾ miles from Dallas.
Hutchins Wagon Bridge.	Iron span, 180 feet...	33	Cylinder iron.	175	18¾ miles from Dallas.
Wilmer Wagon Bridge.	Draw span, 120 feet..	28	Wood.....	30	Under construction, 23¾ miles from Dallas.
Texas Midland R. R...	Iron span, 174 feet...	36	Cylinder iron.	168	50 miles from Dallas.
St. Louis and Southwestern R. R.	Iron span, 200.9 feet.	53	.....do.....	195	115 miles from Dallas.
International and Great Northern R. R.	Two iron spans, 200 feet each.	55.5	Stone.....	85	198 miles from Dallas.

* Not printed.

The general course of the Trinity is southeasterly, with a fall of 189 feet for the 206¾ miles from Dallas to Magnolia.

The height of banks increases gradually from 16 feet near Dallas to 35 feet at Magnolia, with occasional higher bluffs. The banks are stable and show little erosion or caving.

The river flows through a heavy timbered bottom land, 3 to 7 miles wide, which is subject to overflow to a depth of from 1 to 10 feet. These overflows are largely due to drifts and shoals that impede the flow of the river.

Building material useful in river improvements, such as brush, sand, and stone, is found along the river or in proximity to it for the entire length.

Obstructions to navigation are snags, drifts, and overhanging trees.

To clear the river from snags and drifts and to cut timber from banks would involve a cost of $600 per mile, and give a 4 to 6 foot navigation for about four months during the year.

A system of locks and dams for continuous navigation would necessitate the expenditure of $5,000 per mile.

Resources of the river:

Timber.—The area of timber lying along the river from Dallas to Magnolia is about 700,000 acres, which at a low estimate will produce 3,000,000,000 feet of lumber. This is principally hard wood, and consists of oak, bois d'arc, cedar, ash, willow, cottonwood, pecan, walnut, hickory, and elm.

Iron.—Bordering on the river from one hundred and twentieth to the two hundredth mile from Dallas and extending for about 20 miles back from the river are large deposits of brown hematite and laminated ores carrying about 5,000,000 tons per square mile.

Coal.—Outcroppings of coal were found from the one hundred and thirty-fourth to one hundred and seventy-second mile from Dallas in 17 places.

For further statistics I would respectfully refer to the communication of Messrs. Duncan and Griffiths of Dallas (which has been verified by me), and statement * of Mr. Runge, president of Galveston Cotton Exchange.

Accompanying this report will be found a map † of that portion of the river examined in 10 sheets, and a profile † of the same in two sheets.

Very respectfully, your obedient servant,

F. OPPIKOFER,
Assistant Engineer.

Maj. A. M. MILLER,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS OF TRINITY RIVER, FURNISHED BY MESSRS. DUNCAN AND GRIFFITHS, DALLAS, TEX.

DALLAS, TEX., *June 25, 1895.*

MAJOR: Availing ourselves of the permission granted us in our interview with you in Galveston in January last, we herewith beg to submit to your consideration statistics and facts pertaining to the section of country drained by the Trinity River, or that in our opinion would be directly affected by the improvement of same.

We have purposely condensed same for your convenience, and respectfully ask your careful examination and consideration.

We are yours, respectfully,

S. W. S. DUNCAN,
THOS. W. GRIFFITHS.

Maj. A. M. MILLER,
Galveston, Tex.

The map † herewith, showing the watershed of the Trinity River, is an exact copy of a map drawn by the head draftsman of the general land office at Austin, Tex.

The numerous tributaries forming the sources of the river lie between the ninety-fifth and ninety-ninth degrees of longitude, and south of the thirty-fourth degree of latitude. The area of the watershed of above tributaries to McCommas Dam, about 14 miles below Dallas, is about 7,000 square miles. Including the watershed of the east fork of the Trinity, which enters the main river about 45 miles below Dallas by river, the area of the watershed would be about 10,000 square miles. The total watershed of the Trinity would be between 20,000 and 25,000 square miles.

The mean annual precipitation, as shown by United States Government reports (see accompanying maps†), is from 35 to 45 inches, the 35 being more to the westward headwaters of the river. Your survey was made in an exceptionally dry period.

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* Not sent. † Not printed.

The river was lower and nearer dry than persons who have resided in this country for forty years have ever seen it.

By act of the State legislature the Trinity is recognized as a navigable stream to Dallas.

Beginning with and including Dallas County there are fifteen counties bordering on the Trinity River, having an area of 8,813,440 acres, of which 1,178,560 acres are cultivated, or about $13\frac{36}{100}$ per cent. These counties raised in 1894:

Cotton	bales..	356,000
Cotton seed	tons..	178,000
Corn	bushels..	7,500,000
Oats	do...	200,000
Wheat	do...	300,000

The total population of these counties in 1890 was 280,129; assessed valuation in 1892, $91,184,859. The undeveloped resources of these counties we would mention as being (1) land not yet in cultivation, (2) timber, (3) coal, (4) iron, (5) clay, etc.

(1) If afforded better facilities in the way of transportation, the increase in land cultivated in these counties, say 50 per cent of their area, would be a matter of but a short time. The improvement of this section is now being retarded by the lack of sufficient transportation. At least 74 per cent of the land of these counties is capable of a high state of cultivation, and will produce all the cereals and cotton.

(2) *Timber.*—The United States Government estimate of the standing pine in nine of these counties is 15,476,000,000 feet. We have no official estimate of the standing hard woods in these counties, but we are satisfied from our own knowledge that the estimate of the pine can safely be doubled to cover the hard woods. The hard woods comprise several species of oak, ash, elm, magnolia. cottonwood, cedar, etc., in a virgin state awaiting a market. A low estimate of the hard wood in the narrow strip covered by the bottom lands of this river would make, say, 10,000,000,000 feet of sawed lumber. The annual revenue from this timber and the employment of labor and capital would be a new and profitable source of revenue to this State.

(3) *Coal.*—There are large deposits of coal in the counties of Henderson, Anderson, and Freestone that crop out in several places on the banks of the river, the veins ranging from 4 to 12 and 15 feet in thickness. It is estimated it could be loaded on barges in the river at from 25 to 50 cents per ton. This coal outcrops on the river farther down in as many as twenty places.

(4) *Iron.*—According to the State geological reports, there are large areas of iron ore in the counties of Henderson and Anderson, in many places extending to the river. This ore, according to the several analyses, shows from 47 to 56 per cent of pure metallic iron of superior quality, and according to the estimate of the survey there is a large area of this iron that would produce several million tons to the square mile. This ore is all surface ore, requiring no expensive machinery or appliances for mining. This ore could be loaded on barges for 25 cents per ton. While this ore lies almost directly in contact with the coal referred to above, timber also in unlimited quantities exists for the making of the charcoal necessary in the manufacture of iron.

(5) *Clays.*—Fire and other clays, shales, etc., abound, varying from the ordinary brick earths to grades suitable for the manufacture of the ordinary and even finer grades of earthenware.

We consider that we would be very conservative in the following estimate of tonnage for the first few years' navigation of the Trinity if it were improved, with large annual increase within a very short period:

	Tons.
1. Lumber, logs, staves, and shingles	350,000
2. Coal and iron	150,000
3. Cotton seed	50,000
4. Cotton	35,000
5. Grain	15,000
6. Hay	10,000
7. Merchandise and miscellaneous	50,000

For want of transportation none of these products, except the fourth and seventh, are now shipped in or out of this country. This estimate *does not include Dallas County.*

By examination of a railroad map of Texas it will be seen that no railroads parallel this river from its mouth until you reach a short distance from Dallas, except the International and Great Northern, from Palestine to where it crosses the Trinity at Riverside. In the whole river from Dallas to its mouth there are only five railroads crossing the river, and they cross it nearly at right angles, leaving sections of territory between railroads, in the very heart of the richest section of Texas, from 40 to 100 miles in length and breadth that have to rely entirely on wagons for transportation. The improvement of this river to a navigable condition will open to

employment of capital and labor new enterprises in lumbering, mining of coal and iron, and stimulate manufacturing. Too much importance can not be attached to the figure the opening of the Trinity will cut in cheapening the cost of fuel to manufacturers and ocean-going vessels at the port of Galveston.

In the foregoing we have confined ourselves to the counties bordering on the Trinity River. We herewith present our views as to the benefits to be derived by the counties of north Texas, which, we are satisfied, make a convincing argument as to the commercial necessity for the opening of the river.

Forty of these counties had a population in 1890 of 873,173, and according to the State comptroller's report for 1894 had an assessed valuation of $288,780,902. In this territory, within 100 miles of Dallas, there are 757 cities, towns, and villages—one of more than 50,000 population, one of more than 30,000, one over 20,000, several with more than 10,000 each, and 30 with from 1,000 to 4,500 each—with 16,875 business firms, as compared with 27,328 business firms in the entire State. The area of these counties is about 35,000 square miles, or nearly equal to the State of Kentucky, which has about 40,000 square miles. Only 24 per cent of this area is in cultivation, and to show you the rapid increase in products, we will mention the products of cotton only. In the year 1888 these counties produced 414,618 bales of cotton; in 1894 they produced 1,250,000 bales, being nearly one-half of the product of the entire State, which was over 300,000,000 bales.

Considering the immense emigration and the large area of new land that is being annually opened to cultivation, it will only be a few years until at least 50 per cent of this area will be yielding in the same proportion. The value of this cotton we estimate at $45,000,000; other products added will make the total annual production run up close to $100,000,000 per annum.

The total tonnage of this section, as shown by railroad reports, is 4,751,696 tons. Granting that only a small percentage of this tonnage would be handled by the Trinity River, if it were improved, when added to the tonnage directly tributary to the river, it can be easily seen that it will be a judicious investment for the Government and the people, as the tonnage would be over a million tons annually.

The tonnage carried on the Trinity will be carried at water transportation rates. Water transportation rates are cheaper than railroad rates. Railroad rates are always lowered when they come into competition with water rates, and the rates as now charged by railroads in this section are excessive. They will be bound to be governed more or less by the cheap water competition. The annual saving to the people of this section in transporting cotton and cotton products alone has been estimated at $3,000,000. The saving on other products, such as grain, lumber, coal, etc., would amount to at least $2,000,000 more, making a total annual saving of $5,000,000.

As we have referred to Kentucky by way of comparison, we will carry the comparison further. This section, while of about the same area, is about the same population in 1895, and in wealth is making more rapid advancement.

Nearly every stream in Kentucky has received Government aid, and been improved in some instances in the interest of only one or two items of commercial importance. It does look to us that this section should be considered for an appropriation to improve one of its rivers that could be improved for an expenditure amounting to only a small percentage of the annual saving it would bring to the people of this section at the present, and it would be a guaranty to the Government of increased annual revenue from these people from their increase of wealth and production.

The stimulation to manufacturing alone, that owing to excessive freight charges is now impossible in this section, ought to be sufficient reason for our receiving due consideration and an appropriation.

It has been a long-cherished hope of the people of this section that when a harbor should be obtained on our Gulf coast that would accommodate large seagoing vessels that they would be in closer touch with the markets of the world, and be proportionately benefited. Now, at an expense of several millions of dollars by our Government, we are given the port we have been hoping for, and we are by excessive rates charged by transportation companies, aided by ill-advised and unthinking legislative machinery, charged extra for attempting to reach that port, and are compelled to import and export through ports from 350 to 1,500 miles farther removed from us than is our own Gulf port.

To place the actual existing condition of affairs before you in few words and a clear and concise manner, will assert that from 1888 to 1894 and 1895 our products have increased from 100 to 200 per cent, while in 1888 our wheat commanded from $1 to $1.25 per bushel, and our cotton brought us $50 per bale; in 1894–95 wheat sells for 50 cents per bushel and cotton for about $26 per bale, and between 1888 and 1895 our freight rates are increased from 10 to 20 per cent. Increase in population and increase in products, instead of having a cheaper tendency as it does elsewhere, with us acts in a contrary direction.

Government aid to improve the Trinity River is the only source of relief for this

people; it should not be withheld from them, nor should their clamor for relief be unheeded or dismissed with a few lines of comment. Their case deserves careful and conscientious consideration from those who have it in their power to handle their destiny.

The various boards of trade throughout this section have for some time been passing resolutions in regard to the improvement of the Trinity.

S. W. S. DUNCAN,
THOS. W. GRIFFITHS.

S 7.

SURVEY OF EAST END OF GALVESTON ISLAND, TEXAS.

[Printed in House Doc. No. 64, Fifty-fourth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., November 29, 1895.

SIR: I have the honor to submit herewith a copy of report, dated August 26, 1895, with map,* by Maj. A. M. Miller, Corps of Engineers, of the results of a survey for determining the causes of the erosion of the easterly end of Galveston Island, Texas, and estimating the cost of work to prevent the same, made to comply with requirements of the river and harbor act of August 17, 1894.

Major Miller states that in his opinion the causes of the erosion are the violent storms and consequent littoral movement of the almost impalpable sand. In 1885 the city of Galveston built two groins of stone, at the ends of Sixth and Thirteenth streets, to prevent further erosion, and later two additional groins were built—one at the end of Ninth street and the other at the end of Seventeeth street.

Major Miller proposes two methods for protecting the shore—one by a continuation of the erection of stone groins at suitable intervals, at an estimated cost of $90,000, and the other by revetment, estimated to cost $115,000.

Colonel Robert, the division engineer, for reasons given in his indorsement of September 20 on Major Miller's report, states that it would seem best to await further developments before committing the Government to a project for the protection of the shore of Galveston, and I concur in his views.

Very respectfully, your obedient servant,

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

Hon. DANIEL S. LAMONT,
Secretary of War.

REPORT OF MAJ. A. M. MILLER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., August 26, 1895.

GENERAL: In compliance with instructions contained in letter from Office of the Chief of Engineers, United States Army, Washington, D. C., September 8, 1894, * * * I have the honor to report as follows on the survey "for determining the causes of the erosion of the

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* Omitted. Printed in House Doc. No. 64, Fifty-fourth Congress, first session.

easterly end of Galveston Island, and estimating the cost of works to prevent the same:"

The accompanying tracing shows the shore lines of 1838, 1875, 1891, and 1894, all soundings and elevations being referred to mean low water.

The recession of the shore line since 1838 has been quite marked at the extreme end of Galveston Island, but since the construction of the south jetty, completed to Station 320 in 1893, a decided accretion is shown at the extreme eastern end of the island.

The shore line from the foot of Twenty-fifth street to the foot of First street shows a gradual recession, the shore line in the vicinity of Third and Fourth streets, where the erosion has been greatest, showing a loss of about 150 feet from 1891 to 1894.

For the purpose of preventing further erosion, the city of Galveston, in 1885, built two groins of stone at the ends of Sixth and Thirteenth streets, and, in 1892, one at the foot of Seventeenth street, and another at the foot of Ninth street in 1893; these groins have answered the purpose quite well.

The general direction of the movement of sand along the shore is from southwest to northeast, the prevailing winds being from the southwest; the material moved from the city front is arrested and deposited in the pocket formed by the south jetty, and a large accretion has been caused at the eastern end of the island.

The causes of the erosion, in my opinion, are the violent storms and consequent littoral movement of the almost impalpable sand, its fineness greatly facilitating easy movement. It has been suggested by those who claim to have observed the erosion that the building of the south jetty has increased the rapidity of loss, but an inspection of the map shows that it has only had the effect of preventing the further easterly movement of the sand and caused an accretion.

The methods for protecting the shore from erosion are two: First, a continuation of the method already adopted by the city—that is, the erection of stone groins at suitable intervals—and second, a method of revetment.

A revetment of masonry would be very expensive and will therefore not be considered. A revetment of timber, if constructed, would be destroyed by the teredo unless constructed at or above high-water mark; this method would require constant repairs and might eventually be undermined. A proper revetment of 3-inch sheet piling with wale pieces and uprights would cost $8 per running foot; this does not include filling in behind revetment, which would add $2 per running foot to the cost. The amount of shore line requiring revetment is 11,500 feet; this, at a cost of $10 per foot, would amount to $115,000.

The other alternative is the protection of the shore by a system of stone groins, the groins to be normal to the direction of the shore and to be 1,500 feet in length, measured from high-water mark. There would be required four groins, 3,000 feet apart, or 6,000 feet, at $15 per foot, a total of $90,000 for this method.

The method by revetment would have the advantage of providing the riparian owners with a well-defined water front.

Very respectfully, your obedient servant,

A. M. MILLER,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

UNITED STATES ENGINEER OFFICE,
SOUTHWEST DIVISION,
New York, September 20, 1895.

Respectfully forwarded to the Chief of Engineers.

The map accompanying this report shows the shore lines in the vicinity of Galveston for about 4 miles south of the southern jetty, according to surveys made in 1838, 1875, 1891, and 1894. Contours out to 12 feet depth are given for the surveys of 1875 and 1894. Since 1875 the northern end of Galveston Island has been protected by a jetty on the inner side of the island, which has been extended since 1891 to a distance of about 17,000 feet beyond what was the shore line of 1891, and this complete change of condition, to my mind, renders almost valueless a comparison of the surveys of to-day with those of 1838 and 1875. Since 1891, for 9,000 feet south of the south jetty, the shore line has advanced from zero to 1,400 feet, averaging fully 700 feet advance. As Major Miller says:

> An inspection of the map shows that it [the south jetty] has only had the effect of preventing the farther easterly movement of the sand and caused an accretion.

The jetties are to be extended out to the 30-foot curve, and it would seem to be but prudent to have surveys of the shore line made from year to year in the meanwhile, so that the effect of the jetties upon the shore line can be definitely ascertained. As previously stated, the shore has made out for a distance of nearly 2 miles south from the jetty. South of this point to Thirteenth street, a distance of 1½ miles, there has been erosion since 1891 reaching 150 feet at one point, but whether this erosion has increased within the last year we have no data to indicate. The jetty, since 1891, has been extended 2 miles, but we have no means of telling how far beyond the 2 miles mentioned its effect has extended. The extension of the jetty still farther will tend to increase the deposits, and it would seem best to await further developments before committing the Government to a project for the protection of the shore of Galveston.

As to the cost of production, if it were deemed advisable, it seems to me questionable whether it is best to construct jetties of such length as suggested. The map accompanying this report shows that, while the root of each of the small jetties constructed by the city of Galveston is permanent, the shore just north of it, as a general rule, is cut in very close to the jetty, and it seems to me that a number of small jetties, not extending beyond 4 or 5 feet depth of water, and therefore not over 500 feet long, would probably furnish all the protection required at a much smaller cost than with long jetties—say, not over $20,000. If it were afterwards found necessary to add to these, either in length or in number, it could be done without eventually costing for the same protection as much as the very long jetties extending into deep water.

HENRY M. ROBERT,
Colonel, Corps of Engineers, Division Engineer.

S 8.

ESTABLISHMENT OF HARBOR LINES IN GALVESTON HARBOR, TEXAS.

GALVESTON, *May 31, 1895.*

DEAR SIR: The undersigned, composing a committee appointed by the Galveston Chamber of Commerce for the establishment of harbor

lines at the port of Galveston, respectfully call your attention to section 12, chapter 907, of the Supplement to the Revised Statutes of the United States, volume 1, second edition, 1874 to 1891, relating to the establishment of harbor lines, and in that connection respectfully represent—

That the rapid disappearance of the bar at the mouth of the Galveston Harbor in consequence of the Government work in progress here has already stimulated and increased commerce at this port, and promises to augment it in the future to an extent hardly possible of present estimation. This present and prospective increase of commerce makes it imperatively necessary to establish harbor lines beyond which no piers, wharves, bulkheads, or other works shall be extended, or deposits made that will in any manner interfere with the extent or navigability of the waters within the harbor.

In view of this necessity, in behalf of the Chamber of Commerce and the people of Galveston, we respectfully beg that you take such action in the premises as is contemplated by the act above referred to.

Respectfully, yours,

LEO. N. LEVI, *Chairman.*
G. SEELIGSON.
G. E. MANN.

Hon. DANIEL S. LAMONT,
Secretary of War.

[Second indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
June 5, 1895.

Respectfully referred to Maj. A. M. Miller, Corps of Engineers, for report.

If, in the opinion of Major Miller, the establishment of harbor lines at Galveston is essential to the preservation and protection of the harbor, he will submit a chart showing such lines as he may recommend for adoption.

H. M. ADAMS,
Acting Chief of Engineers.

[Third indorsement.]

U. S. ENGINEER OFFICE,
Galveston, Tex., January 3, 1896.

Respectfully returned to the office Chief of Engineers, United States Army, with report of this date.

A. M. MILLER,
Major, Corps of Engineers.

[Fourth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
March 25, 1896.

Respectfully returned to the Secretary of War.

At the request of the Galveston Chamber of Commerce and other interested parties the subject of the establishment of harbor lines in Galveston harbor has been under consideration by Maj. A. M. Miller, Corps of Engineers, who submits the accompanying map,* on which is delineated in red the lines which, in his opinion, should be adopted.

The lines indicated appear to have received the favorable considera-

* Not printed.

tion of all persons directly affected by their establishment, and I recommend that they be approved.

The map has been prepared for the signature of the Secretary.

A. MACKENZIE,
Acting Chief of Engineers.

[Fifth indorsement.]

WAR DEPARTMENT, *March 27, 1896.*

Approved as recommended by the Acting Chief of Engineers.

DANIEL S. LAMONT,
Secretary of War.

[Sixth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
March 31, 1896.

Respectfully returned to Major Miller with the harbor lines recommended by him in reports of January 3 and March 19 approved by the Secretary of War.

When the accurate location of the lines by angles and distances has been indicated on the map, it will be returned to this office.

By command of Brig. Gen. Craighill.

A. MACKENZIE,
Lieut. Col., Corps of Engineers.

[Seventh indorsement.]

NEW YORK CITY, *July 30, 1896.*

Respectfully returned to the Office Chief of Engineers, United States Army, with letter of this date.

A. M. MILLER,
Major, Corps of Engineers.

[Eighth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
August 3, 1896.

Respectfully returned to the Secretary of War.

Under date of March 27, 1896, the Secretary of War approved certain harbor lines for Galveston Harbor, Texas.

Major Miller now submits a description of the harbor lines in accordance with plat approved by the Secretary of War, and also a tracing* upon which the lines have been platted by courses and distances.

It is recommended that the lines for Galveston Harbor described in the accompanying paper and delineated on the chart submitted therewith be approved, this approval to supersede the previous action by the War Department.

The chart has been prepared for the signature of the Secretary of War.

A. MACKENZIE,
Acting Chief of Engineers.

[Ninth indorsement.]

WAR DEPARTMENT, *August 4, 1896.*

Approved as recommended by the Acting Chief of Engineers in the preceding indorsement.

JOSEPH B. DOE,
Acting Secretary of War.

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* Not printed.

LETTERS OF MAJ. A. M. MILLER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., January 3, 1896.

GENERAL: In compliance with second indorsement from the Office of the Chief of Engineers, United States Army, dated June 5, 1895, on communication from the committee appointed by the Galveston Chamber of Commerce, dated May 31, 1895, I have the honor to report as follows:

In my opinion it is essential to the preservation and protection of the harbor of Galveston that proper harbor lines be established.

There is forwarded herewith a tracing showing proposed lines. These lines follow the wharf lines already adopted, and are so drawn that an ample waterway is provided for the tonnage of vessels and the inflow and outflow of the tide.

If these lines as proposed be approved, a proper survey, giving accurate location and description, will be made, and copy forwarded to the Office of the Chief of Engineers.

Very respectfully, your obedient servant,

A. M. MILLER,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

UNITED STATES ENGINEER OFFICE,
Galveston, Tex., March 19, 1896.

GENERAL: Referring to letter from this office, dated January 3, 1896, forwarding a tracing showing proposed harbor lines for Galveston Harbor, Texas, I have the honor to report that the arrangement of the lines was shown to the committee of the Galveston Chamber of Commerce, the president of the Texas City Company, the president of the Galveston Pilots' Association, the general manager of the Port Bolivar City Company, and the representative of the Morgan's Steamship Line (these comprising all persons directly affected by the establishment of the harbor lines), and were found to be perfectly satisfactory to all, except the general manager of the Port Bolivar City Company, who desired the lines in front of their property moved out about 400 feet.

There seems to be no objection to this change, which is shown on accompanying tracing, and I would, therefore, respectfully recommend that after making this alteration the lines be approved as laid down.

Very respectfully, your obedient servant,

A. M. MILLER,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

NEW YORK CITY, *July 30, 1896.*

GENERAL: I have the honor to forward herewith description of harbor lines in accordance with plat heretofore approved by the Secretary of War.

The lines have been carefully platted by courses and distances, and

I would respectfully recommend that the tracing forwarded be substituted for the one inclosed and signed by the Secretary of War.

Very respectfully, your obedient servant,

A. M. MILLER,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

DESCRIPTION OF HARBOR LINES IN GALVESTON HARBOR, TEXAS.

[From a survey of Galveston Harbor and Bay, made in June–July, 1896, for the establishment of harbor lines, including Pelican Island and Spit, Bolivar Point, Virginia Point, and Texas City, county of Galveston, State of Texas.]

The coordinates of starting points in this survey take their origin from Hendley building flagstaff in Galveston City. The Hendley building is situated on southeast corner of block No. 680, in the city of Galveston, as reestablished and determined by surveys of Tipton Walker, civil engineer, and affirmed as the true survey of the city of Galveston by its city council.

The courses are expressed in true compass bearings, with distances in feet and tenths.

When curves are mentioned, they are tangent to the course before the beginning and after the end of each curve.

GALVESTON CHANNEL.

North of Galveston Island and south side of channel between Fort Point and West Bay Bridge of the Galveston, La Porte and Houston Railway.—Beginning at station 84+01 on south jetty, known also as Station U, from which Fort Point light bears N. 53° 47′ 29″ E. 1,939 feet. The coordinates of the above Station U are 9,215.6 N. and 6,197.9 E.; thence S. 43° 06′ 39″ W. 980 feet to a point off old quarantine wharf; thence S. 19° 37′ 05″ W. 700 feet to south boundary of Government reserve at Fort Point; thence S. 17° 35′ 38″ W. 3,000 feet; thence S. 38° 21′ 22″ W. 2,054 feet to east side of Tenth street off Galveston Wharf Company's east boundary; thence S. 38° 28′ W. 241 feet, nearly parallel to front of wharves, to beginning of first curve; thence more or less parallel to present wharves 1,410 feet, curving to the right with a radius of 4,800 feet to end of first curve; thence S. 55° 18′ W. 1,633 feet to beginning of second curve; thence curve to the right 1,073 feet with a radius of 6,600 feet to end of second curve; thence S. 64° 37′ W. 518 feet to beginning of third curve; thence curving to the right 1,963 feet with a radius of 5,000 feet to end of third curve; thence S. 87° 06′ 30″ W. 846 feet to beginning of fourth curve; thence curving to the right 2,301 feet with a radius of 20,000 feet to end of fourth and last curve; thence N. 86° 18′ W. 2,431 feet to east side of Forty-first street off Galveston Wharf Company's western boundary; thence S. 73° 17′ W. 15,800 feet; thence S. 39° 22′ 30″ W. 2,164 feet to the Galveston, La Porte and Houston Railway Bridge over West Bay.

AROUND PELICAN ISLAND AND SPIT.

Beginning at a red navigation beacon on the north side of Galveston Channel from which Fort Point light bears N. 42° 07′ 44″ E. 6,420 feet. The coordinates of the above red beacon are 5,599.4 feet north and 3,455.6 feet east; thence S. 38° 21′ 22″ W. 2,300 feet; thence N. 88° 30′ 06″ W. 4,264 feet; thence N. 61° 52′ W. 14,400 feet; thence north 2,830 feet; thence N. 28° E. 5,650 feet; thence S. 82° E. 5,650 feet; thence S. 61° E. 13,480 feet; thence S. 15° 33′ 31″ W. 2,647 feet to northeast corner State Quarantine Warehouse Wharf; thence S. 13° 23′ 02″ W. 310 feet to southeast corner of State Quarantine Warehouse Wharf; thence S. 17° 35′ 38″ W. 2,908 feet to place of beginning.

AROUND BOLIVAR POINT.

Beginning at survey beacon Alpha, on north jetty, near station 40, from which Bolivar light bears N. 83° 52′ 44″ W. 7,955.4 feet. The coordinates of the above survey beacon are 20,453.4 feet north and 15,677.7 east; thence S. 68° W. 6,800 feet; thence N. 80° W. 4,600 feet; thence N. 59° W. 2,000 feet; thence N. 30° W. 2,500 feet; thence north 3,000 feet; thence N. 11° E. 8,000 feet, toward Baffle Point.

VIRGINIA POINT TO TEXAS CITY, FRONTING GALVESTON BAY.

Beginning at a point on the Galveston, La Porte and Houston Bridge over West Galveston Bay, from which Half Moon light bears N. 23° 04′ 06″ E. 37,731 feet. The coordinates of the above point are 1,408 feet south and 33,461 feet west; thence N. 40° 55′ 23″ E. 3,650 feet off Virginia Point, thence north 19,100 feet; thence N 9° 14′ 36″ W. 3,698 feet; thence north in front of Texas City 2,300 feet; thence N. 16° 28′ 40″ E. 3,963 feet, Shoal Point bearing west; thence N. 9° W. 3,000 feet toward Dollar Point.

APPENDIX T.

IMPROVEMENT OF CERTAIN RIVERS AND WATERWAYS IN LOUISIANA, TEXAS, ARKANSAS, AND MISSISSIPPI, TRIBUTARY TO MISSISSIPPI RIVER; WATER GAUGES ON MISSISSIPPI RIVER AND ITS PRINCIPAL TRIBUTARIES.

REPORT OF MAJ. J. H. WILLARD, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Red River, Louisiana and Arkansas.
2. Red River above Fulton, Arkansas.
3. Cypress Bayou, Texas and Louisiana.
4. Ouachita and Black rivers, Arkansas and Louisiana.
5. Bayou Bartholomew, Louisiana and Arkansas.
6. Bœuf River, Louisiana.
7. Tensas River and Bayou Maçon, Louisiana.
8. Yazoo River, Mississippi.
9. Mouth of Yazoo River and harbor at Vicksburg, Mississippi.
10. Tallahatchie River, Mississippi.
11. Big Sunflower River, Mississippi.
12. Water gauges on Mississippi River and its principal tributaries.

EXAMINATION.

13. Big Sunflower River, Mississippi.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., July 1, 1896.

GENERAL: I have the honor to transmit herewith annual reports upon works of river improvement in my charge for the fiscal year ending June 30, 1896.

Very respectfully, your obedient servant,

J. H. WILLARD,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

T 1.

IMPROVEMENT OF RED RIVER, LOUISIANA AND ARKANSAS.

The Red River of the South has its source in the *Llano Estacado*, in the panhandle of northwestern Texas, and flows in a general easterly direction, forming the boundary between Oklahoma and Indian Territories and Arkansas on the north and Texas on the south. It enters the State of Arkansas about 10 miles north of Texarkana, and from Fulton,

Ark., to Shreveport, La., its course changes to a general southerly direction. Below the latter place its course again changes to a general southeasterly direction, and crossing the State of Louisiana it enters Mississippi River at Red River Landing. The river is about 1,200 miles long. The part included in the project under the title of improving Red River, Louisiana and Arkansas, extends from Fulton, Ark., to the head of Atchafalaya River, Louisiana, a distance of 508.6 miles.

The importance of this great waterway was recognized by Congress as early as 1828, and appropriations for the removal of raft, amounting to more than half a million dollars, were made at intervals between 1828 and 1852. Between 1841 and 1852 no appropriation was made for continuing operations, and a longer period elapsed between 1852 and 1872, during which the results of former work were lost. The lower end of the great raft once was at Natchitoches, if not, as many suppose, still farther downstream, and it extended up the river for more than 100 miles; not in an entire jam, but at intervals, with stretches of clear river between. In 1854 its head had advanced to a point about 50 miles above Shreveport, its length was 13 miles, and it was reported to be forming at the rate of 1½ to 2 miles a year. Between 1855 and 1860 the heavy rates of freight and insurance, and disastrous effects of backwater became so burdensome to the planters that a corporation was chartered under State laws for removal of the raft; the assent of Congress was given to the method of improvement by joint resolution of Febuary 21, 1861, and the company authorized to levy tolls for a period of thirty years. (Stat. L., vol. 12, p. 250.) The company organized and preparations were made to begin work in the spring of 1861, but the war of the rebellion prevented anything being done.

The appropriations for the early work, from 1828 to 1852, were as follows:

Date of act.	General object of appropriation.	Amount.
May 23, 1828	Improving navigation of Red River through or around the raft in Louisiana and Arkansas	$25,000.00
Mar. 2, 1831	Arrearage due Major Burch for survey of raft of Red River, Louisiana	187.50
July 3, 1832	Improving navigation of Red River, Louisiana and Arkansas, being balance of appropriation of 1828 carried to surplus fund, and the further sum of $20,000	22,628.00
June 28, 1834	Improving navigation of Red River	50,000.00
Mar. 3, 1835	Completing removal of obstructions to navigation of Red River	50,000.00
July 2, 1836	Continuing the removal of obstructions in Red River	40,800.00
	Constructing a boat to prevent a new accumulation of obstructions in Red River within the old limits of the great raft, $15,000, and to work and support same, $15,000	30,000.00
Mar. 3, 1837	Continuing the removal of obstructions in Red River	65,000.00
Apr. 20, 1838	The complete removal of the great raft in Red River	70,000.00
Mar. 3, 1841	Removing the raft of Red River	75,000.00
Mar. 2, 1847	Deficiency of appropriation by act of April 20, 1838, being amount advanced by Daniel T. Witlee and others, through the branch of the Real Estate Bank of Washington, Ark., to Henry M. Shreve, Government agent, for removal of great raft, and expended by him for that purpose	7,150.00
Aug. 30, 1852	Removing the raft of Red River	100,000.00
	Aggregate of appropriations, 1828–1852	535,765.50
	Amount expended	532.219.90
	Amount carried to surplus fund	3,545.60

An examination and survey of Red River from its mouth to head of the raft were ordered by river and harbor act approved March 3, 1871, the reports of which are contained in Reports of the Chief of Engineers for 1872, pages 568–573, and 1873, pages 635–676, under which the present improvement commenced in 1872. The original project contemplated removing the raft above Shreveport, La., and closing Tones

Bayou outlet, on the right bank, 19 miles below Shreveport, the gradual enlargement of which diverted a large volume of water and seriously affected navigation of the main river below. Subsequently the project was enlarged to include the removal of jams, snags, wrecks, leaning timber, etc.; opening and enlarging the channel at the Falls of Alexandria, La.; deepening shoal places and closing outlets; fixing caving banks, and constructing and repairing levees to confine the river to the adopted channel, in order to improve and keep navigation open from Fulton, Ark., to the head of the Atchafalaya; also to protect the banks at Alexandria and Shreveport from erosion, and make a thorough and comprehensive survey from Fulton to the Atchafalaya, with a view to permanent improvement of the river.

The appropriations since 1872 have been as follows:

Date of act.	General object of appropriation.	Amount.
June 10, 1872	Improvement of Tones Bayou, Louisiana	$20,000
	Removing the raft in Red River, Louisiana	150,000
Mar. 3, 1873	.....do	80,000
June 23, 1874	.....do	50,000
Mar. 3, 1875	.....do	20,000
Aug. 14, 1876	Removing the raft in Red River and closing Tones Bayou	35,000
Apr. 10, 1869	Allotment made August 27, 1877, for closing Tones Bayou	4,500
Feb. 7, 1878	Opening navigation of Red River above Shreveport, La., and keeping same open and free from rafts, and for the purpose of preserving vessels of United States employed in that work	6,000
June 18, 1878	Removing raft in Red River and closing Tones Bayou	24,000
	Removing snags and other obstructions from Red River	25,000
Mar. 3, 1879	Removing raft in Red River and closing Tones Bayou	15,000
	Removing obstructions from Red River	22,500
	Improving upper Red River, Arkansas, from Fulton to head of the raft	10,000
June 14, 1880	Removing raft in Red River and closing Tones Bayou	25,000
	Removing obstructions from Red River, Louisiana, including construction of snag boat	60,000
	Improving upper Red River, Arkansas, from Fulton to head of the raft	10,000
Mar. 3, 1881	Removing raft in Red River and closing Tones Bayou	10,000
	Removing obstructions from Red River, Louisiana	10,000
Aug. 2, 1882	Continuing improvement from the Atchafalaya to Fulton, Ark., including Bayou Pierre, Tones Bayou, and to relieve the town of Alexandria from encroachments of the river	75,000
July 5, 1884	Continuing improvement from the Atchafalaya to Fulton, Ark.; not exceeding $15,000 for revetment to protect the harbor at Alexandria from damage by the current of river; not exceeding $5,000 to close the outlet known as Sale and Murphy Canal; the remainder to be applied to improvement of the main channel of the river	75,000
Aug. 5, 1886	Continuing improvement from Fulton, Ark., to the Atchafalaya River, Louisiana, including completing the work at Alexandria; $25,000, or so much thereof as necessary, to be used in making a thorough survey of the river from Fulton to the Atchafalaya and in completing survey of Bayou Pierre, Louisiana	75,000
Aug. 11, 1888	Continuing improvement from Fulton, Ark., to the Atchafalaya River, including completing the work at Alexandria; $5,000, or so much thereof as necessary, to be used upon Cypress Bayou and the lakes between Shreveport, La., and Jefferson, Tex., and $5,000, or so much thereof as necessary, upon Bayou Dorcheat	65,000
	Completion of survey from Fulton, Ark., to the Atchafalaya River	35,000
Sept. 19, 1890	Continuing improvement from Fulton, Ark., to the Atchafalaya River; $15,000 to be used in the work at Alexandria; $20,000 to be used in deepening and widening that portion known as Little River, from the Scopini Cut-off to Knox Point, and $5,000 in closing the Sale and Murphy Outlet.	100,000
	Completion of survey from Fulton, Ark., to the Atchafalaya River	28,000
July 13, 1892	Continuing improvement from Fulton, Ark., to the Atchafalaya River, according to plan of Capt. J. H. Willard, Corps of Engineers, and for completion of survey, including the work at Alexandria, the widening of that portion known as Little River, the necessary work at the harbor at Shreveport, the closing of outlets on the west bank of the river above Shreveport, and the removal of the towhead just above Rush Point, Caddo Parish (of which $5,000 may be used, in the discretion of the Secretary of War, for work in Cypress Bayou and the lakes between Shreveport, La., and Jefferson, Tex.)	145,000
Aug. 17, 1894	Continuing improvment from Fulton, Ark., to Atchafalaya River, according to plan of Capt. J. H. Willard, Corps of Engineers, and for completion of survey; $15,000, or so much thereof as necessary, to be used in further prosecution of work at Alexandria, and $5,000 for improving Sulphur River, a tributary of Red River	150,000
June 3, 1896	Continuing improvement from Fulton, Ark., to Atchafalaya River	100,000
	Aggregate of appropriations, 1872 to 1896	1,425,000

The amount expended to June 30, 1895, under the project of 1872 and additions, was $1,197,226.56, resulting in great benefit to navigation. In 1872 the great raft had grown to a length of 32 miles (an increase of 19 miles since 1854), extending from Carolina Bluffs, 33 miles above Shreveport, upstream to within 4 miles of the Arkansas and Louisiana line. Judging from photographs taken before and during work upon this obstruction, it would have seemed easier to cut through rock than to open a navigable river through the mass of tangle that grew higher and larger with each flood. The river above the raft was reached only by devious routes, on either side, through lakes and overflowed lands, and canals dug by private parties who exacted heavy tolls, and those routes were navigable only at stages considerably above low water. A channel was opened through the raft in 1873, and the river as a whole has improved vastly since, both as a navigable stream and as a drain for the great valley through which it flows. The intermittent but frequent attacks of snag boats upon the remains of the raft uncovered by scour has given way for the eroding action of the river, so that it is navigable at far lower stages than was possible even a few years ago. At very low stages, say barely a foot above zero at Shreveport, the river is open to boats of 3 feet draft from Fulton to the Atchafalaya. In the raft region above Shreveport the bottom of the river has gone down as much as 15 feet, the low water line following it to a certain extent, and a similar reduction has been going on below, especially in the stretch known as Little River. The effect has been to lower the general low-water limit, increase the depth, and give greater carrying power to the whole river.

No direct work for the closure of Tones Bayou has been done since 1882. It has been filling up gradually with drift; both arms of Old River at Scopini Cut-off are closed by sand bars to a height considerably above low water, and the natural closing of the outlet has been aided by work of snag boats and ensuing scour above and below. The section of Little River has widened and deepened, and both sides of the stretch have been leveed, so that the proportion of flood water diverted through the outlet at flood stages is small in comparison with former years. Discharge observations taken in 1872 gave about one-quarter to Little River, the rest escaping through Tones Bayou or over the banks into Bayou Pierre; observations taken in 1893 showed that fully two-thirds of the flood was carried down Little River at that time. A few years ago Little River was considered the worst part of Red River for navigation at low stages, but the bottom has scoured until navigation of that stretch is uninterrupted at extreme low water.

The rock excavation and dam at the Falls of Alexandria were completed in 1885, increasing the period of navigation about two months, and permitting boats to pass the falls the year round. The passage, however, was somewhat difficult at low stages, and dredging operations during the low-water seasons of 1892–93 improved the Upper Falls greatly. A crib dam and training wall were built in 1884–85 to protect the bank in front of Alexandria from erosion, and in 1892–93 the structure was strengthened and the caving bank below the influence of the dam revetted with stone excavated from the channel at the Upper Falls.

Work for the general improvement of the river from Fulton to the Atchafalaya, by removing snags, logs, and wrecks in the channel and clearing the banks, was not begun until 1878, former appropriations having been for removing raft and closing Tones Bayou. Since 1885

operations have consisted chiefly of this class of work, and by persistent efforts of snag boats the river has been keep open, raft prevented from forming, the dangers of navigation reduced to a minimum, and steamboats enabled to make regular trips at low stages. Work of the kind will be necessary for many years, as sunken logs and stumps are scouring loose continually and are a source of great danger to low-water navigation; others, thoroughly water-logged, form bars impassable at lowest stages; and the banks of the upper river for hundreds of miles are covered with a heavy growth of timber, which is caving and sliding continually. At high stages the quantity of drift is enormous, and in the old raft region above Shreveport jams form in a few hours, often acres in extent, and require prompt removal before the water falls. Caving banks leave dangerous shore snags projecting far out into the stream, which should be cut after every rise and fall.

The gradual closing of outlets and building up of the levee system, now fully under way, combined with the speedier delivery of rainfall, following the development of the valley, denuding it of timber, and reclamation of lands by drainage, must keep the high-water line up until the river shall have scoured a channel large enough to carry it, when a gradual reduction of flood heights may be expected, provided means are taken in time to prevent waste of energy in caving banks and consequent diminishment of slope below a proper working limit. In 1892 a system of levees was begun by cooperation with the State of Louisiana and local levee boards, extending from the hills just above the Arkansas and Louisiana line downstream. During the three years ensuing a large amount of levee work was completed, aggregating 5,598,360 cubic yards, costing over $852,000, and consisting of about 97½ miles of new work and 52 miles of enlargement. About one-ninth of this work was built by the United States, and the proportion of its cost was about 10 per cent of the total sum.

A thorough survey of high grade was made from Fulton, Ark., to the Atchafalaya River, connecting with the Mississippi by a line of precise level from Delta to Shreveport, La., which continued downstream to the mouth.

OPERATIONS DURING FISCAL YEAR ENDING JUNE 30, 1896.

GENERAL IMPROVEMENT.

In July, 1895, upper Red River had a flood of considerable magnitude, passing the danger line, but subsiding without serious damage beyond the inundation of lands unprotected by levees. A succession of freshets culminated on the 29th and 30th of July in a high-water wave reaching 30.3 feet on the gauge at Shreveport, or 5.4 feet below the high water of 1892. Owing to the long drought which preceded the flood, an enormous amount of drift was contributed, and the rapid rise caused a terrific current.

The United States snag boat *C. W. Howell*, M. B. Lydon, master, was at Shreveport, La., July 1–4, 1895, undergoing repairs of iron bottom, which were pushed as rapidly as possible in order that the boat should be available for service. July 5–7 a patrol of the river was made from Shreveport to Hervey Canal. On the way up extensive side jams were destroyed at Rush Point and Cedar Bluff, and on the return a large pile of drift that had caught on a towhead above Rush Point was removed, and a continuous string of drift all the way down was kept in motion. It appeared at the time that the danger of formation of jams had passed, and after returning to Shreveport the sectional dock

again was placed under the *Howell*, and repairs of the bottom of the vessel were resumed. July 14 the water reached the danger line at Fulton, and calls were made that the boat be sent above Shreveport again. The repairs to the bottom were completed July 15, and the *Howell* left for above. Operations were carried to Fulton July 18, and on the 19th and 20th a large jam of drift was removed at the Texarkana and Fort Smith Railway bridge above that place. A fall having set in, the boat returned to Shreveport July 22. On this trip the drift was continuous, and side jams had to be broken up at short intervals. July 26 the *Howell* ran down to Cotton Point, 57 miles below Shreveport, blew off a point which was causing the opposite bank to cave, and returned to Shreveport July 28. On July 27 the cut-off at Cotton Point in Grand Bend, which had been expected for some years, finally took place. The master of the *Howell* reported that in coming upstream July 26, for a distance of 5 miles above the bend, the current was so strong the snag boat did not make headway of 1 mile an hour with all steam he dare carry, and with water pouring over the boat's head up to the hatches most of the time, and he expressed the fear that the cut-off would make.

As the stages were too high to work to advantage, the *Howell* was laid up at Shreveport until September 3, when a crew was shipped and the boat left for above. Work was carried upstream to head of the old raft region, 65 miles above Shreveport, and all obstructions in the way of navigation were removed, including a large side jam just below O'Rouke Slough, where trees had slipped in from both banks. Complaints having been made of obstructions in the lower river, the boat returned to Shreveport September 14. After cleaning boilers, making minor repairs, and receiving supplies, it left September 17, and carried snagging operations down to Cotton Point, 57 miles below. September 19 to October 2 the crew was employed in building pile dikes for protection of caving banks at Cotton Point, a movable pile driver having been rigged on the forward deck for such purposes. On completion of this work, snagging operations were continued down to head of Atchafalaya River, which was reached October 11. There the boat rounded to and commenced working upstream. The reaches at Grand Point and the Rapions were much obstructed by tree slides and by the banks, heavier than their foundations, forcing the unbalanced bottom up in mud lumps. The stage was lower than at any time of previous work in that part of the river, and advantage of the condition was taken to remove all obstructions thoroughly, to the satisfaction of the steamboat men, who were high in their praise of the work. The brush dams built in October, 1894, to contract the channel at Snaggy Point Bar, were found to have answered all purposes. A bar had formed back of them, and the channel fixed by the dams had scoured until boats experienced no trouble in passing. From Snaggy Point to Swilly Bar, 5½ miles above Alexandria, the channel was cleared thoroughly of snags, logs, stumps, etc. At Swilly Bar the brush dam built in November, 1894, was found intact, and there was 3½ feet depth in the channel, with Alexandria gauge reading 1.3 feet below zero. Above Swilly snagging operations were continued to Shreveport. At Prudhomme Bar there was but 2½ feet depth of channel, and for a distance of about 60 feet at the lower end of Shires there was only 22 inches, but scouring. At the latter place the *Howell* rounded to, backed into the narrow part, and with a few hours' work of the wheel cut a channel 4 feet deep.

Shreveport was reached November 30; two days were spent in making

needed minor repairs, and December 3–24 operations were continued to Cowhide Bayou, 34 miles upstream. The water was at a very low stage the greater portion of this period, and the constant scouring and lowering of the bottom of the river uncovered many snags and logs never before in view. While working at a wrack heap above Briarfield, December 16, a hole was knocked in the bottom of the vessel about 2 feet in length. One compartment flooded, but the leak was stopped and battened and the boat was ready to resume work in about two hours' time. By December 23 the water had risen about 4 feet, but work continued with good results by using the sweep chain over log heaps, which had been dry so long that numbers would rise and float when loosened. December 24 the river commenced rising rapidly, and the *Howell* returned to Shreveport the following day.

December 26 the inspector supervising construction of the levee between Coushatta and Hervey Canal telegraphed that the rise had placed water in the barrow pits in front of Rattling Slough, and asked instructions about protecting that part of the levee. After learning that the *Howell* had reached Shreveport I left Vicksburg by first train December 27, left Shreveport on the *Howell* the following day, and reached the levee the evening of December 29. On the 30th the crew was put to work moving machinery of pile driver ashore, cutting piles, etc., and on the 31st the construction of a pile bulkhead to protect the upper terminus of the levee was commenced under my direction, and was completed January 4. Having inspected the levees along the upper river as high as Blanton Bluff, Ark., I returned to Shreveport on the *Howell*, and January 5 made a trip below Shreveport, inspecting the river and levees as far down as Ash Point. January 6 I inspected the Bayou Pierre and Dixie Levee below Shreveport, partly built by the United States in 1893, and returned to Vicksburg the next day.

January 7 the snag boat *Howell* left Shreveport to return to the Coushatta and Hervey Canal Levee, stopping on the way to blast off a hard-clay point at Herndon Place, which was creating a troublesome bend of the river. The boat reached the levee January 8, and the pile driver was unloaded to build a bulkhead at end of Red Bayou Spur. Failing to find any timber suitable for piling near the locality, the boat ran down to near Gilmer, where 85 piles were cut, taken aboard, and transported to Red Bayou. Construction of the bulkhead commenced on the 11th, and on account of threatening weather was pushed vigorously and completed January 13. January 14–17 the *Howell* remained at the levee, finishing work for protection of both bulkheads, after which it returned to Shreveport, reached that place the night of the latter date, and was laid up in Cross Bayou.

March 27 a small crew was hired and the *Howell* ran down to Tones Bayou for the purpose of strengthening the lower end of the levee across Staten Point, abutting upon Tones Bayou. The bulkhead at end of the spur along Tones Bayou was washed away during the flood of July, 1895, by the water escaping from Red River across Staten Point and through Tones Bayou into Bayou Pierre, and some 50 feet of the spur itself were lost and a deep hole scoured, threatening serious damage to the line unless repaired before high water. The movable pile driver of the *Howell* was taken ashore, cypress piles 12 to 14 inches diameter at butt and 24 feet long were cut in a brake near by, and driven to a depth of 22 feet in a semicircle around end of the levee. The end was graded from top of the levee to bottom of the washout, about 55 feet, to a slope of about 2 base to 1 perpendicular, and the surface protected by a willow mattress lying flat and firmly secured with wire,

the part below the piles being weighted with sacks of earth. This work was completed and the *Howell* returned to Shreveport April 4, where the crew was laid off.

Upper Red River having fallen to a stage of 1.8 feet on the Shreveport gauge, 2.6 feet at Garland, and 3 feet at Fulton, on May 14 I sent instructions to the master of the *Howell* to work from Shreveport to Fulton. A crew was hired, supplies taken aboard, and the boat left Shreveport at 11 a. m. May 19, and in the interval a slight rise set in. Operations were carried to Fulton May 28, by which time the rise had passed and the water was falling rapidly; after completing work in Fulton Reach the *Howell* turned back May 29. The gauge at Fulton May 29 read 4.2 feet, falling, probably the lowest stage on which a boat the size and draft of the *Howell* had reached that place, and to prevent being caught above the bars the boat had to return without delay. Eight to ten years ago a stage equivalent to 11 feet on the present gauge at Fulton (8 feet on old gauge) was the lowest at which a boat would attempt to run to that place..

June 1–7 and 15–30 the *Howell* was employed in improving navigation of Sulphur River, a tributary of the Red, entering the latter 80$\frac{3}{4}$ miles above Shreveport. On June 4 the boat ran down to Shreveport to take on supplies, and on the return trip, June 8–14, the water had reached so low a stage that heavy work in Red River, especially in the old raft region, was necessary before the *Howell* could pass up.

The following is a summary of the work done by the snag boat *Howell* in Red River during the fiscal year ending June 30, 1896, viz:

Snags pulled	1,911
Stumps pulled	587
Shore snags cut	1,555
Logs removed from channel	3,503
Jam removed	1
Side jams removed	30
Leaning trees cut	1,551
Points of land removed with explosives	2
Towheads removed (at Rush Point, La.)	2
Linear feet pile dike built	205
Cypress piles removed from channel, near Fulton, Ark	31
Bulkheads built, for protecting ends of levees	3

Wrecks removed, viz: Part of steamer *Welcome*, sunk 1883, at Rush Point, La., and sunken barge under drawspan of Shreveport Bridge.

Under authority of the Chief of Engineers dated June 18, 1895, an elevator dredge, built in 1892 by the Bucyrus Steam Shovel and Dredge Company for the New Orleans and Northeastern Railroad, at a cost of $26,500, was purchased from the railroad in July, 1895, for $9,500. The dredge had been used for filling in the long trestle which forms the approach of the railroad to the city of New Orleans along the shore of Lake Pontchartrain, and at the time of purchase it was lyiug in the canal dug in execution of the work, near Little Woods. The conveyor ladder, buckets, shears, etc., were taken down, and on August 6 it was towed by a locomotive to the lake at Point aux Herbes. After slight delay in crossing the bar at mouth of the canal it was towed, August 8–9, across the lake and a few miles up Tchefuncte River to Madisonville, where it was hauled out for repairs of hull. The bottom planking, floor, top timbers, keelson, and clamps were found to be in good condition. Choice yellow-pine timbers 30 to 56 feet in length were procured and new sides, ends, and recess put in and well fastened with screw and drift bolts, making the hull stronger than when first built.

The dredge was launched September 10 and found water-tight, and repairs of hull were completed, heavy parts taken aboard and securely lashed, and the vessel put in readiness for towing by September 17. September 22–October 1 a tug took the dredge out of Lake Ponchartrain, through the sounds along edge of the Gulf and up the Mississippi to New Orleans. The stages of the Mississippi were too low for towing upstream at the time, and the dredge remained at New Orleans undergoing repairs until November 16. November 16–19 it was brought to Vicksburg, where the repairs continued. New parts needed were ordered from the Bucyrus Company in December, but were not delivered until the latter part of February. At the close of the year the dredge had been overhauled thoroughly and was ready for work.

This dredge was put to work filling Lake Pontchartrain railroad trestle June 8, 1892, and continued until the end of December, 1894. In this period it moved 684,983 cubic yards, at a total cost, including wages, fuel, supplies, and repairs, of $23,720, or less than 3½ cents a cubic yard. The working hours were from 7 a. m. to 6. p. m., but an average delay of about an hour a day was caused by stops to permit trains to pass, and a considerable number of old stumps impeded progress somewhat.

The dredge is an endless-chain machine, having a steel-frame spoil conveyor 90 feet long carrying a number of steel tube rollers, on which a heavy rubber belt runs at a speed of between 300 and 400 feet per minute. The maximum capacity in good digging is 500 cubic yards per engine hour. The hull is of pine, 86 feet long by 40 feet midship and 14½ feet at ends, 6½ feet deep, and 3½ feet draft. It has a marine boiler 7½ by 7½ feet, rated at 90 pounds; 3 sets of double engines, with condenser and pumps, and extra duplex bilge, deck, and fire pumps, 2 steam spud hoists, rear walking spud, fresh-water tanks, coal bunkers, tools, etc., and a small cabin for quarters has been erected on after end of boiler deck to do away with necessity for a quarter boat.

This dredge will prove a valuable addition to the plant, not only in removing bars for the general improvement of Red River, but it is intended to employ it at various points in the district where dredging is required from time to time and where it will be more economical to do the work by hired labor than by contract, and to make a proper charge, say $25 a day, for use of the machine, to be repaid to the purchase appropriation. The $10,000 available for Cypress Bayou, for example, will pay for at least five times the quantity of work by this method that could be done by contract; say not less than 100,000 cubic yards instead of about 20,000 cubic yards. Contrary to expectations, this kind of machine is found to be well adapted to cutting its way through roots and stumps. I personally inspected the operation of a duplicate machine excavating a drainage canal and embankment near the city of New Orleans through a cypress swamp known as Florida Walk, and am informed that the cost of the work was slightly less than 9 cents per cubic yard.

LITTLE RIVER.

The part of Red River immediately below and narrowed from the influence of Tones Bayou Outlet is called "the Little River," and the act of September 19, 1890, provided a specific allotment for work in the stretch of 17½ miles, from Scopini Cut-off to Knox Point. Under the approved project, work has been carried on in connection with the general improvement of the main river above and below, consisting of

frequent attacks by snag boats, with intervals to allow the river to scour after logs were removed from the bed.

In a letter to the Chief of Engineers dated September 6, 1872, Captain Howell reported respecting this part of the river as follows:

> Bayou Pierre and its main feeder, Tones Bayou, divert over two-thirds of the water passing Shreveport from the main stem of Red River (which even thus depleted affords the only navigable channel to Shreveport), and spreads this out over the unnavigable lakes before referred to, where it is of but little service for purposes of navigation, and where it renders valueless many thousand acres of what would otherwise be as fine land as there is in the State of Louisiana.
>
> The worst part of Red River for navigation during the low-water season is that between the head and foot of Bayou Pierre, the bars affording but from 2 to 3 feet depth of water. Throughout this reach the section of the river is quite uniform in width, and everything appears to favor the opinion that the channel may be greatly improved provided a large body of water can be thrown through it. (Report Chief of Engineers 1873, p. 626.)

Owing to the failure to close Tones Bayou, the conditions reported by Captain Howell continued for many years, and it is only during recent years that a decided change for the better took place. Gradually, however, the effects of the work of snag boats and consequent lowering of the bottom of the river by scour were felt. Whenever practicable, drift was run into Tones Bayou, and, as the bottom of the river went down, both arms of Old River, connecting Little River with Tones Bayou at Scopini Cut-off, closed with bars to a height considerably above low water. The levee system, begun in 1892, aided in confining the flow to the main stream, and the last discharge measurements, made during the flood of 1893, showed that fully two-thirds of the water was carried down Little River.

A report of the Weather Bureau of February 24, 1894, stated the results thus:

> On August 22, 1888, the stage at Shreveport was 4.7 feet above zero. On that date boats could not run. On October 1 and 2, 1893, the stage was 2.6 feet below zero, or 7.3 feet lower than on August 22, 1888, and boats were able to run.

The improvement continued from year to year. The fiscal year ending June 30, 1895, was noted for extraordinary low stages; there was no flood, and the highest reading of the Shreveport gauge was 12.1 feet the last day of the year, 23.6 feet below maximum high water. The river was below zero of the Shreveport gauge for 199 days from July 16, 1894, to January 30, 1895, and again below zero between February 8 and March 11. It was at the lowest known stage, 5.5 feet below zero, December 2–4, 1894, and was over 4 feet below zero from October 20, 1894, to January 24, 1895, or 97 days continuously. However, navigation of Little River was not interrupted by this condition of affairs, for with the reduction of the low-water limit, which has been going on ever since the raft was removed, the general depth has been gaining.

Work during the fiscal year just ended was continued under the plan heretofore pursued, and the stretch known as Little River now affords unobstructed navigation at all stages the year round, and it is my opinion that it can be kept in good condition by occasional work, or work at any special point when required for the immediate needs of commerce. In order that the unexpended balance of the allotment by act of September 19, 1890, shall not be tied up, but used to the best advantage, the recommendation that legislative action be taken to transfer it to the allotment for general improvement, made in my last report, is repeated.

ALEXANDRIA.

The U. S. dredge *Lone Star* and barges were overhauled and repaired at Monroe, La., during the year for use on this work. Work on the dredge was retarded by the rapid oscillations of Ouachita River. It was hauled out on the bank August 19, 1895, both sides and one end were renewed, new top and floor timbers put in where needed, spud casings, and gallows frame rebuilt, etc. On completion of the repairs of hull the river had reached so low a stage that it was impracticable to launch the dredge without great risk, and it remained blocked up on the bank until December 26, when there was sufficient rise to float it. In the interval, general repairs were continued, and the machinery was overhauled and put in good working order. After considerable trouble in obtaining oak timbers of sufficient length, the crane was rebuilt in March, 1896, and the dredge and barges made ready for towing, and April 2–8 the plant was moved from Monroe to Alexandria by the U. S. snag boat *Wagner*.

In order to complete the work at the upper and lower falls to best advantage, it is proposed to make a resurvey of the whole reach from above Bayou Rigollet to a point about 1 mile below the steamboat landing. The cut through the upper falls should be straightened to make easier passage through the eastern draw opening of the railway bridge. Table Rock, which lies about midstream above the lower falls, should be removed, and the passage of the lower falls widened, the material being deposited on the left bank at the root of Bailey Dam. The crib work on the right bank below will be repaired and filled as was done in 1893, and the revetment work repaired and extended.

The people of Alexandria desire a paved levee protection for the city front, but it is not possible to construct it with the funds available, and the work does not seem to be essential to the improvement of navigation at the present time. The work proposed will be undertaken as soon as practicable after the survey, and pushed to completion as promptly as the stages of river permit; present indications pointing to a low stage during the summer and autumn.

CONSTRUCTION OF LEVEES.

Proposals for levee work along right bank of river between Coushatta and Hervey Canal, in Caddo Parish, La., were opened July 15, 1895, as per abstract appended to this report.

Contracts with the lowest bidders were entered into July 25, 1895, and approved by the Chief of Engineers August 5, 1895. They provided for commencement of work on or before September 2, 1895, and completion by December 31, 1895. The locality was barren of labor, difficult of access, wild in character and overrun with insects, harassing and injurious to stock. The flood of Red River in July, 1895, and unusually high stages for several weeks after, prevented work beginning with full force as soon as expected, and kept the ground soft for some time, and as September was excessively hot, with much sickness at the levee camps, both men and teams had to be favored. In view of these circumstances, the Chief of Engineers, under date of December 26, 1895, authorized extensions of the contracts to February 15, 1896.

The work was let in two sections, and completed as follows:

Elmer Bayou section consisted of raising and enlarging on the river

tide, to a net grade of 3 feet above highest water, the levee built by the State of Louisiana and Caddo Levee District Board in 1892–93, beginning at an angle of same about 4,500 feet below Elmer Bayou, about 46 miles above Shreveport, and extending upstream. Michael Hunt, contractor; price 13½ cents per cubic yard. Work commenced August 26, 1895, and completed February 13, 1896. Length of line, 24,198 feet. Total quantity of enlargement, 70,393.8 cubic yards.

Red Bayou section is a new levee, connecting with the upper end of Elmer Bayou section, built to same grade, and continuing upstream toward Hervey Canal, including a heavy dam closing Red Bayou. The available funds were not sufficient to carry it to and across Hervey Canal, as intended originally, and the upper terminus was secured by a pile bulkhead. William J. Bentley, contractor; price, 13.89 cents per cubic yard. Work commenced August 18, 1895, and completed February 15, 1896. Length of line, 13,731 feet. Total contents, 284,326.7 cubic yards.

The following table, furnished by the board of State engineers of Louisiana, shows in a concise manner the work on Red River undertaken during the fiscal year by the State and the levee districts:

Levee work on Red River undertaken by the State of Louisiana and local levee districts under contracts entered into during the fiscal year ending June 30, 1896.

Name of contract.	Parish.	Below Fulton.	Date of—		New levee.	Enlargement.	Quantity.	Price per cubic yard.	Cost.	Per cent of work done.
			Contract.	Final certificate.						
Caddo levee district.										
By the State:		*Miles.*			*Linear feet.*	*Linear feet.*	*Cu. yards.*	*Cents.*		
Egypt enlargement	Caddo	145.25 148.25	Sept. 17, 1895	Jan. 27, 1896	.....	14,752	21,762	9.89	$2,152.26	100
Uni and Briarfield	do	155 158	Nov. 4, 1895	Feb. 26, 1896	.....	16,975	32,747	9.49	3,107.69	100
Riverdale*	do	202 209 213.5 215.25	do	.....	5,105	9,323	74,320	9.74	7,238.76	85
Total	.....	.....	.....	.....	5,105	41,050	128,829	.....	12,498.71	
By the district:										
Coushatta ramp	Caddo	143.5	.....	Dec. 23, 1895	.....	.....	941	10	94.10	100
Rush Point	do	155	.....	Nov. 11, 1895	935	.....	4,646	8	371.68	100
Wilderness	do	158 159	Aug. 20, 1895	Mar. 10, 1896	7,570	1,830	88,307 13,232	20 25	20,969.40	100
Tones Bayou ramp	do	206.5	.....	Nov. 11, 1895	.....	.....	609	10	60.90	100
Total	.....	.....	.....	.....	8,505	1,830	107,735	.....	21,496.08	
Bossier levee district.										
By the State:										
Taylor†	Bossier	162.5 168	Nov. 18, 1895	May 4, 1896	3,040	24,645	90,870	9.73	8,954.35	100
Red River, Atchafalaya, and Bayou Bœuf levee district.										
By the State:										
Echo Landing‡	Rapides and Avoyelles.	425 428.5	Sept. 11, 1895	Apr. 18, 1896	10,881	5,477	154,977	8.89	14,277.45	100
Total work undertaken	.....	.....	.....	.....	§ 27,531	‖ 73,002	482,411	.....	57,226.59	

* Includes work at Brown, Cash, and Long Branch; all completed except Long Branch section, 12,000 ± cubic yards.
† Includes enlargement at Willow Bend and $112.70 for repair of banquet. ‡ Cost includes $500 for repair of Dorman Levee. § Or 5.21 miles. ‖ Or 13.83 miles.

The following extract from a report of the board of State engineers of Louisiana to the Caddo Levee district commissioners, dated August 6, 1895, coincides with the views repeatedly expressed by me, and it is hoped that by united action of the General Government, the State, and local levee boards the making of cut-offs will be prevented and proper action taken for the care and protection of levees during periods of continued low water:

During the late high water in Red River the cut-off at Cotton Point, in Grand Bend, which has been expected to occur for some years past, finally took place. To any one familiar with the situation the work done by Mr. Stringfellow, in extending the levee line across Cotton Point, should, therefore, be recognized as an opportune and valuable adjunct to your levee system, not to speak of the benefit it will prove to the many in Red River Parish below.

An incipient attempt was, about the time of the occurrence of the cut-off in Grand Bend, made to assist the river to cut through the narrow neck in Lovely Point. Fortunately it failed this time, but the risk of its succeeding at some future period of high water has increased.

In regard to cut-offs, their development should, in our opinion, be regarded with grave apprehension rather than favor by both the local riparian proprietor and the community. This department looks upon the question of repeated cut-offs in so tortuous a stream as Red River with unqualified disfavor, believing that it means a continuance of serious disturbances in the regimen of the river, which must tend to retard the work of establishing that uniformity of section and adjustment of slope so necessary to insure the future stability of its banks and the ultimate reduction of high-water levels.

* * * * * *

As a further record of events, since your last session, reference should be made to the recent high water in Red River. A succession of freshets in the upper river finally culminated on the 29th and 30th of July in a high-water wave registering 30.3 on the gauge at Shreveport, or 5.3 below the high-water mark of 1892. From such information,.however, as it has so far been possible to definitely obtain, the stage of the river at points above and below where the improved conditions of the river are, from local causes, not so pronounced as others, the difference between the height of this water and that of the highest of record did not exceed 1½ feet.

No abnormal conditions existed this year that did not exist in 1892 and 1894. On the contrary, the conditions this year tended to a reduction of flood levels.

The inference, therefore, is that a flood wave but little differing in proportions from that of 1892 and 1894 passed down the river, this time registering only 30.3 on the gauge at Shreveport against 35.6 for 1892 and 34.4 for 1894, and that this result is due to the material enlargement of Red River within recent years, in consequence of the greater confinement of its waters to the main streams by means of levees and the progress made by the General Government in the removal of obstructions from its bed.

Without going too deeply into details, this conclusion should be patent to any one who has given the matter any degree of attention, and who has had access to the reports of the stages of the river published by the United States Signal Service Bureau, say since 1889. These show that the low-water line at Shreveport has dropped from 0.2 of a foot below the zero of the gauge in 1890 to 5½ feet below the zero of the gauge in 1894. During all these years navigation on Red River, such as it is in periods of extreme low water, was as good as, if not better than, during the years preceding, when the low-water line was above the zero of the same gauge—in some years as much as three feet. The conclusion readily suggests itself and, with a continuation of this deepening of the channel and enlargement of the section of Red River, demonstrated at Shreveport and elsewhere, flood heights, as given on the present gauge at Shreveport, will no longer be a safe indication of the proportions of the wave passing that point as compared with the readings for past high waters on the same gauge.

This last view should, we think, be particularly considered and borne in mind by your people below Shreveport, and our remarks on the subject are submitted as a note of warning against drawing conclusions in the future as to probable effects in the lower river, based upon the stage of the river as given upon the present gauge at Shreveport. The premises of the past will not, in our opinion, maintain.

The board of State engineers, however, wish it to be distinctly understood that it does not advance the belief that the high waters of the past will not be exceeded, but that, if the recent improvement in the capacity of the Red River continues, the high waters of the future will each season be carried down with less risk and danger to the levees and the interests of the valley.

The work of enlargement is steadily going on wherever Red River is confined, either by natural or artificial banks, but it must necessarily be slower in certain

reaches, where adverse conditions must, through force of circumstances and the absence of means, be temporarily tolerated and suffered, than in others.

This is notably the case within the limits of your district, for some miles below Cottonwood Bayou and below Tones Bayou, which, now that the closure of Red Bayou this season is assured, are the only remaining outlets from Red River of any magnitude, or of any special influence upon the river and its rectification within the limits of the district.

The levee line in your district, with one exception, does not seem to have been subjected to any very severe experience during this last high water. The exception referred to was at the lower end of the levee across Staten Point, abutting upon Tones Bayou. Here the bulkhead at the end of the spur, on the upper side of the levee, was washed away by the water escaping from Red River across Staten Point and through Tones Bayou into Bayou Pierre. Some 50 feet of the spur itself was also lost. The bulkhead at the end of the spur on the lower side of the levee was threatened with the same fate, but by the timely and energetic efforts and work of Mr. W. V. Robson it was saved.

The accident to this work is, of course, a source of disappointment, but the damage sustained by the main line is so slight in comparison with what it would have been, had these bulkheads—unstable as they proved—not been built, that your board should not by any means be discouraged.

Timely attention, no doubt, would have saved the upper as well as the lower bulkhead, but the place being somewhat isolated, the fact that it was in danger was not learned in time. Eternal vigilance along your whole line is the only safeguard against accident when the river is against your levees. The damage to the spurs and bulkheads at Tones Bayou should be repaired before the next season of high water.

It may not be out of place to refer once more to the fact that your levee system, notwithstanding the amount and excellence of the work accomplished since the organization of your board, is still far from complete. A considerable length of the river front of your district still remains unleveed, and from many causes numerous places in the existing line require rebuilding and repairing. The care, preservation, and protection of your line, too—including the guarding against abuses—has not yet been accorded anything like the systematic and effective consideration which it imperatively demands.

The board of State engineers would respectfully urge that these facts be borne well in mind, and will be pleased at any time to supply the detailed information necessary for you to further any work in the direction suggested.

The present condition of the levee system on Red River is summarized in the report of the board of State engineers of Louisiana, dated April 20, 1896, as follows:

On Red River there are continuous stretches of levee, as follows:

(1) From Blanton Bluff, Lafayette County, Ark., to lower side of Sale and Murphy Canal, Caddo Parish; a length of levee line down Red River, right bank, of 3 miles.

(2) From a point about 3 miles above Red Bayou to Hurricane Bluff Plantation; a length of levee line down Red River, right bank, in Caddo Parish of 22.5 miles.

(3) From upper side of Bayou Pierre to upper side of Tones Bayou, a length of levee line down Red River, right bank, in Caddo Parish, of 12.5 miles.

(4) From a point on Bayou Pierre, in Caddo Parish, 9 miles below Tones Bayou, to near Bayou La Chute, in Red River Parish; a length of levee line up Bayou Pierre and Tones Bayou, left bank, and down Red River, right bank, of 36 miles. About 9 miles of the upper end of this stretch (i. e., the line of Bayou Pierre) and about 2 miles of the lower end (i. e., the part in Red River Parish) were built by private parties, and are not considered as district levees.

(5) From the high lands near Hurricane Bluff to the Buckhorn plantation, a length of levee line down Red River, left bank, in Bossier Parish, of 55 miles.

(6) From a point on Bayou Rapides about 2.5 miles above Alexandria to Labordes, about a mile above Choctaw Bayou, a length of levee line down Bayou Rapides and Red River, right bank, in the parishes of Rapides and Avoyelles, of 37.5 miles.

(7) From "The Junction" of Bayou Rouge and Bayou des Glaizes, Avoyelles Parish, to the Texas and Pacific Railroad embankment at Melville, St. Landry Parish; a distance by the levee line down Bayou des Glaizes and the Atchafalaya River, right bank, in Avoyelles and St. Landry parishes, of 66 miles, of which about 30 miles on Bayou des Glaizes has not yet been improved and enlarged to the same extent as that in other parts of this district.

There are other stretches of levee of less length and importance and a number of detached dikes, closing outlet bayous, etc., along the Red, Ouachita, Black, Tensas, and Little rivers. Some of them have been built or enlarged since 1882 by the State or by other public authority, though most of them are not usually taken into account as forming parts of the public levee system.

* * * * * *

On Red River the systematic construction of public levees has, so far, been confined to the Caddo, Bossier, and the Red River, Atchafalaya and Bayou Bœuf Levee districts, and, while the work done by the combined efforts of the boards of commissioners of these districts, the State, and the United States has been prosecuted with energy and foresight and aggregates amounts of considerable magnitude in length of line and earthwork handled, much still remains to be done in these districts in the way of extension, improved grades and sections, and in drainage to insure an equal degree of security throughout their lengths, not to speak of immunity from overflow.

Among the most important extensions to the existing lines in these districts that should first command attention are in the order named in the districts:

1. In the Caddo Levee district, the gap from Sale and Murphy Canal to the Red Bayou Levee, recently completed by the United States Government; from the Hurricane Bluff plantation to Shreveport, and ultimately the closure of Tones Bayou.

2. In the Bossier Levee district from Buckhorn plantation to Swift Chute Bayou.

3. In the Red River, Atchafalaya, and Bayou Bœuf districts, in Avoyelles Parish, from Labordes, across Bayou Choctaw, to the Avoyelles prairies.

The extensions above mentioned are more or less necessary for the protection of the levee districts as now incorporated. A considerably greater extension of levees would be necessary for the protection of other territory subject to overflow not now included in any of the levee districts.

In undertaking the extension named in the Red River, Atchafalaya, and Bayou Bœuf Levee district, the question of diverting the drainage of the large basin lying between Red River and Bayous Robert and Bœuf, from Red River, where it now finds its principal escape, during low water, into Bayou du Lac, Bayou des Glaizes, and the Atchafalaya, or by canal into Bayous Bœuf and Courtableau, or partly by both of these channels, must not be lost sight of.

The extent to which the improvement in the grades and sections of the levees in these districts must be eventually carried will depend largely upon the lessons to be learned from the future conduct of the river, when, in its changed condition, by reason of confinement, it will be put to a test by the great floods that will at some time or other again visit it. Enough, however, is now known to select the following localities as requiring such enlargement: In the Caddo Levee district, from Crescent Place to Briarfield, and with the closure of Tones Bayou from the upper side of Bayou Pierre to Caspiana; in the Bossier Levee district, from Willow Bend to Dillards, and with the closure of Tones Bayou, from Curtis to Knox Point; in the Red River, Atchafalaya, and Bœuf Levee district, from Bayou Rapides to Hudsons.

Again, Red River for its greater length is in a state of rapid development, entailing great changes in direction, width, and depth, and the caving consequent upon this must, from time to time, in many places jeopardize not only the lines of levees thus far built, but retire the natural banks on other parts of the river now supposed to be sufficiently elevated to restrain floods to so much lower ground that lines of levees will thus become imperative in many localities, the necessity for which is not generally appreciated by the riparian dwellers at this time.

Viewed from these standpoints, the board of State engineers believes that the work required for extending the system, adjusting grades and sections to such dimensions as developments may impose, closing breaches caused by future caving, and for the disposition of interior drainage interrupted by the extension of the levees, will demand the best efforts of all interested in the welfare and prosperity of the Red River Valley for a long while to come.

The estimates for levee construction submitted in my last report amounted to $450,000, and the total appropriated for Red River by the act of June 3, 1896, was $100,000, which, following the custom that has obtained since August 2, 1882, must be presumed to cover work to June 30, 1898. The gap in the Caddo system from Sale and Murphy Dam, the end of the levee line which begins at the hills known as Blanton Bluff, to the upper end of the levee built last season to a point about a mile below Hervey Canal, corresponds to about 12 miles of river. This gap should be closed at the earliest practicable date, and the State engineers and Caddo Levee board had great hope that it would be provided for in the bill this year. The country is a difficult one, thinly settled, and not easy of access, and the work would involve a great amount of clearing of heavy timber and long haul for earth. From the general map I estimate the total embankment required to complete this line at not less than 1,500,000 cubic yards and the cost of the work at $300,000. The State and Caddo board can not contribute more than their good will and services for some years, and as they are pressing

the work on the United States it will be necessary to give careful study to the problem to decide whether to undertake any part of it or to apply the funds that may be allotted to levee construction to other places. It is my opinion that the line ought to be extended from Sale and Murphy at least 2 miles to carry it across O'Rouke Slough, which would require from 200,000 to 250,000 cubic yards, and cost between $40,000 and $50,000.

While applying funds to levee construction for the purpose of improving navigation it has been the endeavor of the engineer in charge to aid the Bossier and Caddo boards impartially, the establishment of the system being of the first importance to them. The Red River, Atchafalaya, and Bayou Bœuf Levee district has not yet been helped by the United States, and the people living within it feel that the time has come for them to urge their claims. Levees are essential in the improvement and maintenance of Red River, and large appropriations should be made for that purpose. It is proposed to go over the whole ground with the State engineers at an early day, and to decide upon the best application of the funds for the general good.

SULPHUR RIVER.

The river and harbor act of 1894 provided that $5,000 of the appropriation for Red River, Louisiana and Arkansas, should be used for improving Sulphur River, a tributary entering Red River in Arkansas 80¾ miles above Shreveport, La. The approved project for expenditure of the amount provided for the removal of snags, logs, leaning timber, etc., obstructing navigation by using one of the snag boats when near that stream, thereby saving the cost of additional plant and of organizing a separate party.

A favorable opportunity for doing the work did not present itself during the fiscal year 1895, nor until late in the year just passed. The U. S. snag boat *Howell*, M. B. Lydon master, made a trip over Upper Red River between Shreveport, La., and Fulton, Ark., the latter part of May, 1896, and was ordered to work in Sulphur River on the way down. The snag boat reached the mouth of this tributary May 31, the gauge at that place reading 65.50 meters, Cairo datum, or 2.21 meters above the lowest stage of previous record (December 2, 1894, 63.29 meters.) The master of the *Howell* made an examination of the stream for about 10 miles above its mouth and found the obstructions to consist of snags, stumps, sunken logs, etc., in the channel, and a heavy growth of leaning timber. Work commenced June 1 and continued for three days. On the morning of June 4 the boat left for Shreveport to procure supplies, intending to return at once, but owing to the low stage of Red River was obliged to work its way back, and did not reach Sulphur River until the morning of June 15. In this interval the river had fallen 1.73 meters, reading 63.77 meters, Cairo datum, on the Collins Bluff gauge at mouth of the river, June 15, and the banks had commenced to cave and slide, breaking away for distances of 50 to 100 feet back, forcing the bottom up, and disclosing a compact interlacing of logs, snags, and stumps. The *Howell* pushed upstream 1½ miles, as far as it could go with safety, and finding upon further examination that the obstructed condition continued to within a mile of the Texarkana and Shreveport Railroad Bridge, or for a distance of about 7 miles above the mouth, it was compelled to back out to Red River June 18. After that date the crew continued work with axes, saws, and tackle, removing leaning timber, stumps, and other obstructions except

those in deepest water, which were left until a slight rise would permit the snag boat to return. A supply of dynamite was shipped from Vicksburg June 17 to destroy the heavier logs and snags, but its delivery by rail was delayed until the end of the month. At the close of June work had been carried up to Fort Lynn, Ark., about 8 miles above the mouth. The water continued to fall, and on June 30 reached the extreme stage of 63.30 meters, Cairo datum, on the Collins Bluff gauge, and still falling.

The following is a summary of the work done:

Snags removed from channel	60
Stumps removed	1,376
Shore snags cut	72
Logs removed from channel	122
Leaning trees cut	2,739

A large amount of drift is carried into Sulphur River during the inflow at flood stages of Red River, and the stream is so sluggish that most of it remains. This probably accounts, to a great extent, for the badly obstructed condition of the stretch immediately above the mouth, as the stream above the Texarkana and Shreveport Railroad Bridge to Sulphur Station is said to be in fairly good condition.

Logging is the only business done on the river at present, but it is stated that people of Texarkana interested are preparing to build a warehouse at the Texarkana and Shreveport Railroad Bridge, with a view to receiving river shipments and receipts of that city, 24 miles distant by rail.

GENERAL REMARKS.

No intelligent plan for the permanent improvement of Red River can be submitted until final report upon the survey. The subject of general improvement was discussed somewhat extensively in my report for 1894 (Report Chief of Engineers, 1894, p. 1430), and I can add but little, except to repeat that the time seems near when permanent improvement should be undertaken. The late Major Howell recommended a lock and movable dam at Alexandria, perhaps the only site where safe foundations could be got, but the local need has passed, since the falls are navigable for any class of boats that can reach Alexandria. An open river is to be preferred, as a rule, and the large amount of sediment and the enormous quantities of drift carried by Red River in time of flood would prove serious objections to a slack-water navigation. For the present, therefore, the best plan will be to continue removal of snags and obstructions for the immediate needs of trade and to assist nature by extending the levee system so well started under the provisions of the act of July 13, 1892.

Reviewing the amount of work done by cooperation with the State engineers and levee boards, the United States will be seen to have borne very much less than a fair share of the expense, and therefore I renew the large estimates of my last report.

The working plant should be kept as small as possible, but there are some additions required, such as pile drivers, barges, etc., which are required now.

As to dredging, etc., it may be well to delay for a year or so to see how the experiment of removing bars in Mississippi River turns out. Comparing by scale, success on Mississippi River would warrant experiment with smaller centrifugal pumps and engines set up temporarily on the steamers now in service, like the *Howell*, without any material increase in running expenses, and success on Red River would have great weight in deciding the question of improvement.

A large amount of office work remains to be done before submitting final report upon the survey of Red River, which has had to be laid aside for lack of men to do it, the assistants and draftsmen having been in the field or engaged upon notes of Ouachita River survey. The estimate includes the following work: Title and information sheet; index charts, 3 sheets, scale, 1:200,000; legends, borders, and finish of 64 sheets of survey, scale, 1:10,000; tracing 17 sheets of resurvey of 1893–94 to show changes by caving, cutoffs, and levee construction; profiles and cross sections of original survey, 21 sheets; reducing and plotting 1,277 sections of resurvey of 1893 and 360 sections of 1894; local sections of 1872, 1875, 1879, and 1881 to be reduced to same datum and scale; high and low water sections to be scaled and areas of discharge measured by planimeter. It would be advantageous to check the levels above Shreveport, especially at Fulton or Garland, by a line of precise levels over the Iron Mountain Railway from Gurdon, or over the Cotton Belt Route from Camden to Garland, the starting point being permanent benches of the levels of precision established on the line from Little Rock to Camden for Ouachita River survey. The precise levels of Red River survey were carried from Coast Survey bench at Delta Point, opposite Vicksburg, to Shreveport, and thence down to Coast Survey bench below the mouth of Red River, while the levels between Fulton and Shreveport were duplicated wye levels. In addition to checking the levels of the survey the results would benefit the gauge service by fixing the elevations of zeros of gauges on the river from above Texarkana to Shreveport. The total cost of the levels, including monuments, transportation, and office computations, is estimated at $4,500, which, with the cost of finishing the maps and other work, will require $7,500 for completing the survey. If the maps should be printed, $2,500 more would be needed for a small edition.

ESTIMATES.

Additions to plant, pile drivers, barges, etc	$50,000
Care of plant and ordinary repairs	15,000
New steel bottom for snag boat *Howell*	10,000
Service of snag boats, dredges, chopping parties	50,000
2,250,000 cubic yards of levee	450,000
Completing survey	10,000
Local surveys, maps, gauges, etc	10,000
Administration, contingencies, etc	5,000
Continuing snagging operations, clearing banks, etc., above Fulton, Ark., to Kiamichi River, Indian Territory	10,000
Total	610,000

The amounts expended during the year and balances July 1, 1896, are as follows:

Allotments.	Expended during year.	Balances July 1, 1896.
For general improvement, repairs, and care of plant, etc	$29,114.48	$10,097.09
For Little River from Scopini Cut-off to Knox Point (act of Sept. 19, 1890)	1,882.48	11,117.37
For work at Alexandria, La	5,276.61	9,703.63
For survey of Red River	1,070.37	.....
For construction of levees	51,074.22	3,437.19
For Sulphur River	1,357.42	3,642.58
	89,775.58	37,997.86
Appropriated by act of June 3, 1896; not allotted at close of year	.....	100,000.00
	.....	137,997.86

Money statement.

July 1, 1895, balance unexpended	$127,773.44
Amount appropriated by act of June 3, 1896	100,000.00
	227,773.44
June 30, 1896, amount expended during fiscal year	89,775.58
July 1, 1896, balance unexpended	137,997.86
July 1, 1896, outstanding liabilities	68.81
July 1, 1896, balance available	137,929.05
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	610,000.00

Abstract of proposals for enlargement and construction of levees on Red River between Coushatta and Hervey Canal, Caddo Parish, La., received in response to advertisement dated June 26, 1895, and opened at Vicksburg, Miss., July 15, 1895, by Capt. J. H. Willard, Corps of Engineers.

[Price per cubic yard.]

No.	Name and address of bidder.	Elmer Bayou section.	Red Bayou section.
		Cents.	*Cents.*
1	Barbour, Ruple & Leeper, New Orleans, La	16.70	16.35
2	Lemuel A. Bauman & Jesse Thomas, Shreveport, La	16.94	15.94
3	Eltringham Construction Co., Natchez, Miss	.....	17.90
4	John Scott & Sons, St. Louis, Mo	.....	16.7
5	Garbish & O'Neil, Ashwood, La	15.94	16.39
6	William J. Bentley, New Orleans, La	15	*13.89
7	Israel R. Bobbitt, Bayou La Chute, La	15.375	14.40
8	Charles H. & John M. Dameron, Huntsville, Mo	.....	19.98
9	William V. Robson, Robson, La	13.75	17.50
10	Robert S. Doles, Roswell, La	16.88	.....
11	Michael Hunt, Missionary, La	*13.50	.....

* Bid accepted.

REPORT OF MR. H. M. MARSHALL, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., June 27, 1896.

MAJOR: I have the honor to submit the following report on the survey of Red River, Louisiana and Arkansas:

Work has been entirely confined to the office. Topographical signs have been filled in on the remaining twenty map sheets, scale 1:10,000. Resurvey of 1893 has been plotted and eight of the sheets added to the tracings, leaving seventeen sheets not yet complete. Eighty-two profile sheets have been plotted showing banks, bed, high and low water, with cross sections at frequent intervals. Twenty-one sheets remain to be done, and resurvey of 1893, also local surveys of 1894, and earlier years, are yet to be added. The notes for this are only partially reduced.

Employment of the engineer force on other works with lack of funds for this has for some time kept the work at a standstill. The expenditure required to put the data in available shape for a basis for a plan for river improvement is no small item either of money or mental effort, but without proper coordination to prepare a plan would be like making bread from the garnered grain without grinding or bolting. With an allotment from the funds recently appropriated the work can be completed and a special report made within a few months.

Very respectfully, your obedient servant,

H. M. MARSHALL,
Assistant Engineer.

Maj. J. H. WILLARD,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

The river was reported navigable in the fiscal year as follows: From Shreveport to Fulton for light-draft boats the entire year, with the exception of September; from Shreveport to the mouth there was navigation for light-draft boats the entire

year. The regular Red River and New Orleans packets ran to Shreveport the entire year, with the exception of the period from October 1 to December 31, 1895, when they could go only as high as Coushatta, La. The mouth of Red River was navigable the entire year.

List of steamboats engaged in the trade during the fiscal year 1896.

Name.	Class.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Between—	Round trips.	Passengers.
						Light.	Loaded.			
			Feet.	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*			
Imperial	Stern wheel.	494.69	210	40.6	6.6	3 0	8 6	Shreveport and New Orleans.	14	242
Valley Queen	...do ..	410.83	190.6	35.8	5.6	3 0	8 6	....do Grand Ecore and New Orleans. Rushpoint and New Orleans.	15 1 1	456
Anna B. Adams	...do ..	315.49	157	31.6	3.1	1 6	3 6	Shreveport and New Orleans. Shreveport and Garland. Moreau Landing and New Orleans.	3 13 1	67
Hallette	...do ..	265.9	161	30.5	4.5	2 6	6 6	Shreveport and New Orleans. Coushatta and New Orleans. Montgomery and New Orleans. Campté and New Orleans. Pecan Point and New Orleans. Williams Landing and New Orleans.	8 2 2 1 1 1	136
Alvin	...do ..	201.55	143	29.1	7.1	.....	.....	New Orleans and Red River.	1	.....
W. T. Scovell	...do ..	154.23	160	31	3.7	1 8	5 0	Shreveport and New Orleans. Coushatta and New Orleans. Natchitoches and New Orleans.	5 2 1	86
Rosa Bland	...do ..	148.71	113.2	22.8	4.4	1 6	3 6	Shreveport and Elmer. Shreveport and Garland. Shreveport and Mooringsport.	39 18 6	427
Royal	...do ..	44.82	86.6	24	3	1 2	3 0	Fulton and Garland.	25	.....
George L. Bass*	...do ..	53.82	91	21	3.3	1 6	3 6	Coushatta and Baton Rouge. Knox Point and Baton Rouge.	1 1	....
H. W. Graves†	...do ..	31.22	94.6	17.6	3	1 4	3 0	Campté and local landings above and below.	63	.....
Osceola	...do ..	24.39	.....	.....	.....	1 2	3 0	Alexandria, Montgomery, and Cane River.	20	.....
Jo. Walker	...do ..	59.48	80.4	20	3	1 0	3 0	Shreveport and Whitehall.	....	.....
C. R. Watkins	...do ..	59.24	81.5	36	3.8	.....	.....	Alexandria and Pineville Ferry; hourly trips.	....	.....
New Jennie*	...do ..	66.43	104.1	28.2	4.1	.....	.....	Shreveport and New Orleans.	1	.....
Des Arc†	...do ..	40.88	95	18	3	1 2	2 6	Grand Ecore and Cane River. Natchitoches and Cane River.	5 5	....
Nellie L.†	...do ..	8	.....	.....	.....	2 0	2 6	Shreveport and Missionary.	13	.....
Lee Otis†	Tug...	10	40	9	5	4 0	4 0	Alexandria and Barbin Landing. Alexandria and Okalan.	25	.....

* Towboats.

† With one or more barges.

Summary of commerce reported.

Articles.	1895–96.	1894–95.	1893–94.	1892–93.	1891–92.	1890–91.	1889–90.	1888–89.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Cotton	13,204	18,308	15,392	14,061	29,400	21,613	18,838	12,593
Cotton seed	18,537	5,322	4,402	7,902	31,832	12,249	14,140	11,975
Cotton-seed meal	4,822	4,516	9,042	4,713	.....	10,000	.....	.....
Live stock	55	49	496	1,185	286	38	.....	32
Hides and skins	71	50	31	62	151	212	35	97
Lumber	1,570	1,657	1,257	1,520	2,352	.....	4,519	.....
Saw logs	18	20,000	28,869	15,200	22,250	16,523	.....	.....
Staves	380	697	228	1,739	206	81	58	.....
Stone	.....	.....	.....	.....	.....	.....	.....	4,600
Miscellaneous	2,285	3,000	105,395	5,964	14,107	2,719	136	373
Total down freight	40,942	53,599	165,112	52,346	100,584	63,435	37,726	29,670
Return freight	32,560	22,122	63,518	17,605	19,942	30,051	28,650	19,780
Total	73,502	75,721	228,630	69,951	120,526	93,486	66,376	49,450
Estimated value	$3,833,000	$3,419,000	$6,061,000	$3,422,000	$6,877,000	$9,185,000	$6,820,000	$5,370,000

In addition to the above, from Ouachita River entering Red River at mouth of Black River, 118,017 tons, the value of which is estimated at $5,123,000.

The following newspaper clipping is of interest in connection with the subject of commerce of Red River:

"The following is a full mention of the cargo brought by the *Imperial* from Red River, estimated by her officers to be equal in weight to 4,400 bales of cotton, and the largest of the kind on record. The items were 108 bales cotton, 13,619 sacks cotton seed, 2,500 sacks cotton-seed meal, 1,567 sacks cotton-seed oil cake, 125 barrels cotton-seed oil, 32 barrels and 5 boxes empty bottles, 2 bales moss, 3 coops poultry, 7 cases eggs, 133 bundles empty sacks, 1 barrel wax, 62 packages furniture, 5 sacks wool, 2 sacks potatoes, 1 sack onions, 5 empty barrels, 1 cotton-gin saw, 1 cotton-gin brush, 4 packages merchandise. The credit of having brought the largest Red River cargo on record is very satisfactory to her officers, but when the stage of water upon which this work had to be done is considered they can certainly take great pride unto themselves. In one part of the river she could not load to over 4 feet, for there was about 4½ feet water. Some distance lower down she was loaded to 5 feet large, on a 5½-foot depth, and coming out loaded, drawing 7½ feet, she found but 9 feet with the stick."

Receipts and shipments of bales of cotton at Shreveport, La.

	1895–96.	1894–95.	1893–94.	1892–93.	1891–92.	1890–91.	1889–90.	1888–89.
RECEIPTS.								
By rail	42,860	52,573	30,033	25,277	44,256	39,890	25,476	30,331
By wagon	31,474	54,968	41,014	31,612	49,644	37,725	40,026	35,450
By river	6,679	11,319	5,581	4,821	9,189	14,836	8,897	12,368
Warehouse receipts	81,013	118,860	76,628	61,710	103,089	92,451	74,399	78,149
SHIPMENTS.								
By Texas and Pacific Rwy	22,631	34,239	25,019	26,904	36,645	23,311	23,690	20,582
By Vicksburg, Shreveport, and Pacific R. R	10,441	20,239	10,546	10,384	23,251	15,564	20,813	24,029
By Houston and Shreveport R. R	16,582	22,459	13,429	3,114	5,353	13,860	12,529	494
By St. Louis Southwestern Rwy	16,869	28,469	17,817	7,818	24,187	15,039	8,820	24,125
By Kansas City, Pittsburg and Gulf R. R	100	.....	.....	.....	.....	.....	.....	.....
By river to New Orleans	14,102	10,654	9,246	14,751	10,567	19,218	8,412	8,956
Total	80,725	116,060	76,057	62,971	100,003	86,992	74,264	78,186

The competing routes of transportation for the trade of Red River Valley, below Fulton, Ark., are as follows: The river is crossed by the St. Louis, Iron Mountain and Southern Railway at Fulton, Ark., by the St. Louis Southwestern Railway (Cotton Belt route) at Garland, Ark., and by the Vicksburg, Shreveport and Pacific Railroad at Shreveport, La., and a branch of the Cotton Belt system from Lewisville, Ark., 8 miles east of Garland, runs parallel to the river to Shreveport. The Texas and Pacific Railway runs nearly parallel to the river and touches at Alexandria, Boyce, Shreveport, and other points on the main river, and at Jefferson, Tex., on Cypress Bayou,

and connects at Texarkana, Ark., with the Cotton Belt and St. Louis, Iron Mountain and Southern. Morgan's Louisiana and Texas Railroad, a branch of the Southern Pacific, runs from Alexandria to the main line. Shreveport is the eastern terminus of the Houston and Shreveport Railroad. The Houston, Central Arkansas and Northern Railroad, a branch of the Missouri Pacific system, crosses the river about 1¼ miles above Alexandria. The Kansas City, Watkins and Gulf Railway runs from Lake Charles, La., on the Southern Pacific, to Alexandria, and is building eastward to Natchez, Miss., and another line is projected to cross at Alexandria. Jefferson, Tex., at the head of navigation of Cypress Bayou, has transportation by the Missouri, Kansas and Texas Railway, in addition to the Texas and Pacific Railway mentioned above. The Texarkana and Shreveport Railroad is built from Texarkana to Doddridge, Ark., about 6 miles from the mouth of Sulphur River. The Texarkana and Fort Smith Railway, Texas Division of the Kansas City, Pittsburg and Gulf Railroad, projected from Kansas City, Mo., to Sabine Pass, Tex., touches the river at Shreveport, and is building southward with expectation that the entire line to Sabine Pass will be in operation by January 1, 1897.

T 2.

IMPROVEMENT OF RED RIVER ABOVE FULTON, ARKANSAS.

An examination of Red River above Fulton, Ark., was made in 1884, in compliance with river and harbor act of that year, and the plan recommended for its improvement contemplated removing snags, drift, etc., to secure safer high-water navigation to the mouth of Kiamichi River, Indian Territory, about 138 miles above Fulton. The cost of the work was estimated at $10,000 if granted in a single appropriation. (Report Chief of Engineers, 1885, pp. 1617–1627.) In 1889 an additional appropriation of $2,000 was asked for to be applied to going over and completing the work. After the expenditure of this amount it was recommended that nothing further be done unless a single appropriation of not less than $10,000 be granted to allow the systematic clearing of the banks and removal of logs from the channel.

The appropriations have been as follows:

By act of—		By act of—	
August 5, 1886	$7,000	August 17, 1894	$3,500
August 11, 1888	3,000	June 3, 1896	3,000
September 19, 1890	2,000		
July 13, 1892	3,500	Total	22,000

The amount expended to June 30, 1895, was $18,056.67. The original project was completed in 1891 at a cost of $11,774.89. The appropriations of 1892 and 1894 were applied to maintenance of the improvement. Details of the work done were given in my last report. (Report Chief of Engineers, 1895, pp. 1882, 1883.)

No work was done during the fiscal year ending June 30, 1896.

The commerce and navigation of Red River above Fulton as yet are so limited that it is not believed that any extensive improvement is required at present, and the recommendation made in my report of 1891 and repeated each year since remains applicable, viz:

> This part of the river is navigable for the smallest boats, and during high stages only. Lanesport, Ark., near the Indian Territory line, 74 miles above Fulton, usually is considered the upper limit of navigation, but boats make occasional trips to Kiamichi on the highest stages of river. Below the Kiamichi, Red River has no tributary of consequence except Little River, which enters the main stream 2 miles above Fulton. The oscillations are so rapid that frequently boats can run in one direction only on a single rise, and have to regulate their trips by the quantity and duration of rainfall in the upper river country.
>
> The banks are covered with trees constantly caving or sliding into the river, and if the removal of obstructions from the channel were continued and the timber cleared from the banks to stop further accumulations, navigation would be safer and there would be less drift to contend with in the river below Fulton, but it is doubtful if the boating period would be lengthened or the upper limit extended.

I recommend one of two courses in regard to this part of Red River; either that no further work be done in it until there shall be a pressing demand for a considerable improvement from Fulton upward, including Little River, both to gain a better and longer period of navigation and to help drain the adjacent lands, or else that a liberal amount, say not less than $10,000, shall be given in a single appropriation to allow the systematic clearing of the banks and removal of logs from the channel way to permit the bottom to scour. In no other way can the money be expended economically or any appreciable results obtained. The cost of organization and administration will be about the same for a small appropriation as for a large one, and the cost of getting the plant to the scene of operations and returning it to the fleet or other work will reach together nearly $1,000. The estimate is submitted with the idea of sending all the snag boats in Red River to work together under one management just as soon as the spring floods begin to subside, the snag boats to be employed on the wrack heaps and heavy obstructions and the chopping parties to clear the banks, so that all loose stuff shall go out on the first and succeeding rises. This will allow about six weeks' to two months' work of the snag boats, the lightest-draft boat being kept perhaps somewhat longer, and the boat with the chopping party continuing on downstream on bank work and small jams. About $1,000 should be held in reserve to send a snag boat over the whole the following season to dislodge heavy drift and pick up channel snags.

The act of June 3, 1896, provided only $3,000 for continuing improvement of Red River above Fulton. There is no plant belonging to this work, and it can not be let advantageously by contract. I can devise no plan by which the appropriation can be expended with greater economy and advantage to the United States than the following: When one of the snag boats is employed near Fulton, it is proposed to continue operations above that place as far as the boat may be able to work, to mouth of Kiamichi River if practicable, and, if driven out by a falling river, to resume operations from time to time as circumstances will permit; the plan being that instead of ceasing snagging operations at Fulton, under the project for improving Red River from Fulton to the Atchafalaya, they shall continue above that place until the appropriation is exhausted. Local navigation will be benefited, but the chief gain is to the river below, in reducing the amount of drift. The improvement is worthy to be continued in this manner, but it is recommended that it be done hereafter by allotment from the appropriation for Red River, Louisiana and Arkansas, instead of a separate item of appropriation, and for these reasons the estimate for its continuance is included in the report for that work, and future operations will be given under the general head of improving Red River.

Money statement.

July 1, 1895, balance unexpended	$943.33
Amount appropriated by act of June 3, 1896	3,000.00
	3,943.33
June 30, 1896, amount expended during fiscal year	2.89
July 1, 1896, balance unexpended	3,940.44

COMMERCIAL STATISTICS.

List of stern-wheel steamboats engaged in navigation during the year.

Name.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Between—	Round trips.
					Light.	Loaded.		
		Feet.	*Feet.*	*Feet.*	*Ft. in.*	*Ft. in.*		
Royal	44.82	86.6	24.0	3.0	1 2	3 0	Fulton and Lanesport	5
							Fulton and Little River	20
Jennie Gilchrist	74.48	105.5	18.5	3.8	.....	.....	No report	...

With the exception of a small quantity of timber and staves, there was practically no river commerce in Red River above Fulton in the fiscal year 1896. The light-draft steamboat *Royal* made five short and profitless trips during the year. The cotton crop was greatly reduced by the overflow in July.

The river, from the mouth of Kiamichi, the upper limit of the improvement, to Fulton, is paralleled by a branch of the Texas and Pacific Railroad from Texarkana to Paris, Tex., connecting at the latter place with the St. Louis and San Francisco Railway, a branch of the Atchison, Topeka and Santa Fe system, which crosses Red River at Arthur, Tex. The Texarkana and Fort Smith Railway crosses the river about 10 miles north of Texarkana, and the St. Louis, Iron Mountain and Southern Railway crosses at Fulton, Ark.

T 3.

IMPROVEMENT OF CYPRESS BAYOU, TEXAS AND LOUISIANA.

The improvement of the waterway from Jefferson, Tex., down Cypress Bayou, across Fairy and Sodo lakes, and through Twelve-Mile Bayou to Shreveport, La., under the designation "Improving Cypress Bayou," was commenced under river and harbor act of 1872. From 1872 to 1879 sums aggregating $94,000 were appropriated, and with this amount cuts were dredged in Cypress Bayou and from the bayou into the head of Fairy Lake, and leaning timber, sunken logs, and stumps were removed from the navigable channel. At the beginning of the work it was stated that dredging would make a limited improvement only, by rendering navigation easier and safer at high and medium stages, but that the navigable season would hardly be prolonged. In 1879 Major Benyaurd made no estimate for continuing work, but reported:

> There are no more cut-offs that can be made to advantage, nor dredging to be done on the bayou, for when steamboats can pass Sodo Lake there is sufficient water in the channel above for all navigation purposes. In the lakes the dredge would be of no service. It is proposed during the next low-water season to send a working party across the lakes and cut down and remove all the cypress stumps and other obstructions in the channel already selected. When this work is executed it will give good navigation to Jefferson at a time when there is sufficient water for that purpose, and will complete the project previously submitted.

In 1874 Captain Howell discussed various plans for improvement, the most favorable of which then appeared to be the construction of a dam across Sodo Lake at Albany Point and a dredged cut through to Red River at Gold Point. (Report Chief of Engineers, 1874, pp. 706–720.) No action upon this plan was taken by Congress, but the river and harbor act of July 5, 1884, directed that a resurvey be made "to ascertain if the necessary improvement could not be made upon some other plan than building a dam across the Albany Flats." An examination of the route was made, and it was found that the dredged cuts had shoaled and that the channel was more or less obstructed by stumps, etc. January 5, 1885, Captain Bergland submitted a project for reopening the cuts in the bayou and at head of Fairy Lake, removing stumps from the shoal water at Albany Flats and through Sodo Lake, making the entire depth available for navigation; straightening the channel in Fairy Lake and removing stumps to a depth corresponding to that obtained in Sodo Lake, and marking the channel selected through the lakes with signboards. It was estimated that this work would cost $18,000 and secure safe navigation between Jefferson and Shreveport for seven to eight months of the year. The act of 1886 appropriated $18,000, which was applied to carrying out the project. The act of 1888 alloted $5,000 of the appropriation for Red River to this work, which was applied to going over the route and removing obstructions. The act of 1892 provided that $5,000 of the appropriation for Red River

might be used, in the discretion of the Secretary of War, for work in Cypress Bayou and the lakes, and during the low-water season of 1893 the sum of $1,701.33 from this allotment was expended in going over the entire line from Shreveport to Jefferson, removing stumps, etc., in the channel and leaning timber along the banks of the bayous. This work put the stream in good navigable condition at any stage high enough to permit boats to pass Sodo Lake. Since 1888 the lakes and bayou have been navigable from seven to ten months of the year.

By resolution of the House of Representatives, February 6, 1890, a special report was called for respecting the improvement of Cypress Bayou and the lakes, and was submitted February 26, 1890. (Report Chief of Engineers, 1890, p. 1914.) This report contained an index of all former reports, the essential portions of previous examinations and plans, and statement of work done under them, and was the basis of an extended survey provided for by river and harbor acts of 1890 and 1892 for the purpose of ascertaining if navigation could be materially and permanently improved by construction of dams or locks and dams.

Final report upon the survey was made in 1893 (Report Chief of Engineers, 1893, p. 2065), with a plan for improving navigation between Shreveport and Jefferson by building a dam with waste weir across Sodo Lake, with entrance from Red River through Cottonwood Bayou by a lock with double gates. The cost of the work was estimated at $375,000, and the plan was discussed at length, with reasons in full for and against its advisability. The limited commerce to be benefited in comparison with the original cost of the work, annual charges of operation and maintenance, and the fact that the probable life of the improvement could not be estimated, rendered the question of the United States entertaining the project doubtful, to say the least, and this view appears to have been taken by Congress, as the river and harbor act of August 17, 1894, provided $10,000 "for dredging and removing obstructions and straightening channel between Jefferson, Tex., and Shreveport, La."

This appropriation appears to have been based upon a paragraph in my report upon the survey, reading as follows:

> Considering the needs of Jefferson alone, I should recommend improving the present channel from Jefferson to mouth of Twelve-Mile Bayou by removing the logs and cypress stumps, widening it by dredging, easing the curves, clearing the banks of the bayou of leaning timber, and marking the channel by clusters of piles, beacons, and buoys. This route would be navigable for boats that could cross the Albany Flats, and, since there are no questions of drainage or discharge to be considered, the route could be shortened by cut-offs at every practicable place. With the route thus improved the only danger to navigation would be that of being blown out of the channel by high winds, which, however, could not be avoided even with slack-water navigation.

The appropriations for Cypress Bayou and the lakes have been as follows:

By act of—	
June 10, 1872	$10,000.00
March 3, 1873	50,000.00
August 14, 1876	13,000.00
June 18, 1878	15,000.00
March 3, 1879	6,000.00
August 5, 1886	18,000.00
August 11, 1888 (allotted from appropriation for Red River)	5,000.00
September 19, 1890, for survey	10,000.00
July 13, 1892, for survey	2,000.00
July 13, 1892 (allotted from appropriation for Red River)	1,701.33
August 17, 1894	10,000.00
June 3, 1896	5,000.00
Total	145,701.33

Operations under the act of 1894 have not commenced, there being no plant available, and the long distances a dredge would have to be towed, to and from the work, rendered a contract inexpedient, as a large proportion of the appropriation would be required to cover the cost of towage, etc.

A ladder dredge of the Bucyrus Company's make was purchased at second-hand last summer, at moderate cost, for use in Red River and upon other works of the district. This boat has been undergoing repairs at Vicksburg, and it is the intention to use it upon this work as soon as practicable; a reasonable charge for the service to be repaid into the appropriation from which the dredge was purchased.

Money statement.

July 1, 1895, balance unexpended	$10,187.74
Amount appropriated by act of June 3, 1896	5,000.00
	15,187.74
June 30, 1896, amount expended during fiscal year	.82
July 1, 1896, balance unexpended	15,186.92

COMMERCIAL STATISTICS.

The small steamer *Rosa Bland* made six trips between Shreveport and Mooringsport, La., during the year, but the amount of business done could not be ascertained. About 10,000 tons of saw logs, valued at $200,000, were floated to the mills at and near Jefferson. Beyond this no commerce was reported. The people of Jefferson claim that the difference between railway and steamboat rates on cotton to New Orleans is $1.85 per bale, the former charging $3.75 and the latter $1.50 and 40 cents insurance, with similar differences on other freights, and that the construction of the Kansas City, Pittsburg and Gulf Railroad Bridge across the lake at Mooringsport, La., obstructed the channel and prevented shipments by the water route during the period of navigation. The railroad officials contend that the obstruction referred to was temporary piling preparatory to putting the draw of the bridge in place, and that if a boat had come along it was the intention to remove as many bents as necessary to allow it to pass. Also that the railroad company was willing, and, in some instances, did pay the difference between railroad and river rates from Jefferson to Shreveport while the channel was blocked by false work.

T 4.

IMPROVEMENT OF OUACHITA AND BLACK RIVERS, ARKANSAS AND LOUISIANA.

Ouachita (the Indian name for black) River has its source in Polk County, Ark., and following an irregular course flows in a general southeasterly direction through Arkansas and Louisiana until joined by Tensas and Little rivers at Trinity, La. Below this junction it is known as Black River and flows in a southerly direction, entering Red River 35 miles above its mouth. The entire length of Ouachita River is about 500 miles, and that of Black River is 47 miles.

Under river and harbor act of 1870 an examination of Ouachita River was made (Report Chief of Engineers, 1871, pp. 334–346), and work commenced in 1871 under a project for temporary improvement from Arkadelphia, Ark., to Trinity, La., by removal of snags, etc., and dredging the worst bars. A survey from Camden to Trinity was ordered by act of 1871, the report on which recommended improvement by locks and dams. (Report Chief of Engineers, 1872, pp. 367–374.) The project contemplated building five timber locks and dams, to last about twenty-five

years, and to give 4 feet depth from Trinity to Camden, at an estimated cost of $1,163,083.75, exclusive of maintenance. Contracts were made for timber for foundations of three locks, but after a resurvey, completed in 1874, which showed faulty location of dams, that the locks proposed would be too small, that the least cost would be $2,626,252, and that locks would be idle at the time intended for use until a permanent improvement should be obtained at mouth of Red River, it was considered inadvisable to continue the work, and the project was abandoned. The contracts for timber were annulled, material on hand sold at auction, proceeds turned into the Treasury, and the available funds applied to construction and operation of a snag boat.

The project under which work below Camden has continued since 1874 contemplates the removal of snags, logs, wrecks, leaning timber, etc., obstructing navigation, and the improvement of shoals by dams and dredging. Black River was added under the same head of appropriation with Ouachita by act of 1884. The distance from Camden to mouth of Black River is 341 miles. No estimates of cost are given, as the nature of the work requires that it be continuous.

The appropriations have been as follows:

Date of act.	Locality.	Amount.
Mar. 3, 1871	Between Arkadelphia, Ark., and Louisiana State line	$25,000
Do	Between Arkansas State line and Trinity, La	26,000
June 10, 1872	Between Arkadelphia, Ark., and Louisiana State line	60,000
Do	Between Arkansas State line and Trinity, La	40,000
Mar. 3, 1873	....do	60,000
Aug. 14, 1876	Between Camden, Ark., and Trinity, La	12,000
June 18, 1878	....do	10,000
Mar. 3, 1879	....do	10,000
June 14, 1880	....do	8,000
Mar. 3, 1881	....do	12,000
Aug. 2, 1882	....do	12,000
July 5, 1884	Between Camden, Ark., and mouth of Black River, Louisiana	15,000
Aug. 5, 1886	....do	17,500
Aug. 11, 1888	....do	20,000
Sept. 19, 1890	....do	15,000
July 13, 1892	....do	40,000
Aug. 17, 1894	Between Camden, Ark., and mouth of Black River, Louisiana, including survey	50,000
June 3, 1896	Between Camden, Ark., and mouth of Black River, Louisiana, and for completion of survey	70,000
	Total	502,500

The total amount expended to June 30, 1895, was $403,655.77. The amount expended from July 1, 1874, to June 30, 1895, was $272,241.25, which was applied to operations under the project of 1874, and to beginning a survey, with a view to slack-water navigation, required by act of 1894. The iron-hull snag boat *O. G. Wagner* was purchased for the work in 1875, and repaired with a new steel bottom in 1886. Under provision of the act of 1888 the small wooden steamer *Col. Hooker* was purchased that year and fitted up for light snagging, and in 1894 it was rebuilt and the name changed to *Columbia*. Since 1875 operations were carried on whenever funds were available and conditions favorable, and consisted chiefly of removing snags, logs, wrecks, and tree slides in the channel and cutting leaning timber. An increased depth was gained at some of the shoals in the upper river by inexpensive wing dams built of stone and brush, the temporary effect of which, however, has been lost. Catahoula Shoals, a place much complained of by steamboat men, was improved permanently by dredging through the rock and gravel bar, completed in January, 1895; 82,518 cubic yards of material having been removed.

To comply with requirements of the act of 1894, a survey was commenced for the purpose of preparing plans and estimates for an improvement by locks and dams, to give slack-water navigation as far above the mouth of Ouachita River as practicable. Levels of precision were considered of first importance, and during the fiscal year 1895 the line from mouth of Black River to Monroe, La., was completed, and a line was run from the Coast Survey benches at Little Rock, Ark., along the railroads to Camden, and thence to Frenchport, 13¼ miles below Camden, where work was suspended by unfavorable weather. The notes of former surveys were reviewed to obtain all information available, and a reconnoissance from Camden to Trinity was made to recover and permanently mark old benches, compare maps of 1873, etc.

Operations during the fiscal year ending June 30, 1896, were as follows:

GENERAL IMPROVEMENT.

The U. S. snag boat *Wagner*, Watkins Decker, master, remained at Monroe, La., undergoing minor repairs, until September 11, 1895. By that time the river had reached a low stage, and the work of removing obstructions below Monroe commenced and was continued until November 25, when, the funds available for snagging operations, etc., being nearly exhausted, the crew was discharged and the boat laid up at mouth of Bayou Louis, above Harrisonburg, La., and 108½ miles from Monroe.

During this period Ouachita River was at an exceptionally low stage, probably the lowest known, and effective work was done. The *Wagner*, with fuel and supplies aboard, draws 33 inches, and in the prosecution of the work between Monroe and Bayou Louis pulled over nineteen sand and gravel bars, viz: Gem, Fenner, Faulk, Bres, Taylor, Dunn, John Faulk, Bosco Belle, Cut-off, Castor, Minden Hall, Columbia, Nichols, Thompson Bayou, Wade, Hogan, Stamper, I. M. Davis, and mouth of Big Creek. The depths upon these bars ranged from 18 to 30 inches, the least depth, 18 inches, having been found at Fenner and Castor bars.

A low-water channel sufficient for the *Wagner* was cleared of obstructions from Sheats's sawmill, near Monroe, down to Castor Landing, and from Columbia to mouth of Bayou Louis. Between Castor Landing and Columbia it was impracticable to work at the low stage, as more time would have been spent in pulling the boat over shoals than in removing obstructions. It was intended to return to this stretch, if there had been a slight rise before the funds ran out, but the opportunity did not occur.

The places notably improved were as follows: At Sheats's sawmill, Dowdy woodyard, and Noble plantation the channel was blocked with nests of snags, which were removed; 3 large snags and 1 stump were removed while pulling over Taylor Bar; stumps and snags brought in by a slide were removed just below Dunn Bar; 3 snags were removed while pulling over John Faulk Bar; and a slide of stumps, trees, and snags between Lefeta and Rose Landing was removed. At Columbia Landing the wreck of the steamer *Edna*, sunk in 1848, was removed, and th bend below the town was cleared of snags. Between G. W. Bridger' and Thompson Bayou the channel was cleared of snags and the stretch dragged up and down with sweep chain, affording an immediate increase of depth of 8 inches, with channel scouring rapidly. At Wade, Hogan, and I. M. Davis plantations barely 30 inches of water were found, but after removal of obstructions there was more

than 3 feet depth in channel. Eight snags were removed from Stamper Bar, and 5 snags were removed from channel at mouth of Big Creek. The remains of the wreck of steamer *Idaho*, sunk in 1869 near Neal Landing, and partly destroyed in 1893, were removed from the channel. Twenty-five snags on Bayou Louis Bar were destroyed with explosives. This bar is caused by trees and logs which caved and slid from the banks and became embedded in the bottom. As they are removed the bottom scours, exposing others, which require removal from time to time. The bank has been cleared of timber, and it is believed that repeated attacks of the snag boat will cause the bar to disappear in the near future.

The *Wagner* laid up at Bayou Louis until December 30, undergoing minor repairs of machinery, wheel, etc. December 30 to January 2 it returned to Monroe, taking the two survey quarter boats in tow at Mrs. Gibson's Landing.

The following is a summary of the work done by the *Wagner* during the year, viz:

Number of miles run	260½
Number of miles worked over	68¼
Snags pulled	466
Channel snags destroyed with explosives	25
Stumps pulled	55
Stumps cut	61
Shore snags cut	284
Leaning trees cut	47

Wrecks removed, 2, viz: Steamer *Edna*, sunk in 1848 at Columbia, and steamer *Idaho*, sunk in 1869 near Neal Landing. Also removed shaft of wreck of steamer *Mary Louise*, below Stock Landing. Towed survey quarter boats from Gibson Landing to Monroe.

The stretches worked over were put in good condition for navigation at stages on which steamboats can cross the bars, and an increased depth of 12 inches was gained at some of the bars from the scour following the removal of obstructions. The work is not permanent, as sliding and caving banks bring in logs, snags, and stumps, from time to time.

The stretch between Columbia and Castor Landing should be worked over by the snag boat at a stage slightly above low water, and a patrol made from mouth of Black River to Camden to remove large obstructions brought in since the last work was done.

On account of numerous bars and shallow water, a snag boat can not operate in the upper river, from Monroe to Camden, at extreme low stages, and during the period of low water one or more chopping parties should work over this part of the stream, thoroughly clearing caving banks and sharp bends, and using high explosives to destroy channel obstructions. After completion of such work, when the water reaches a navigable stage, a snag boat should go over the stretch to remove jams of drift, floating butts, etc.

October 1–10, 1895, all portions of the wreck of the old wharfboat *Memphis*, in the way of navigation at Monroe, were removed. This boat sank a number of years ago at the foot of Grammont street, just below the bridge. It was broken up with dynamite, and the débris hauled out and burned. The work was done under the supervision of G. W. Phillips, engineer of the United States dredge *Lone Star*, laid up at Monroe at the time.

CATAHOULA SHOALS.

The work at this shoal, completed in January, 1895, appears to be permanent. At extreme low water, in the fall of 1895, 5½ feet depth was found through the cut, and the banks on both sides showed no

evidences of caving or sloughing. The current has cut through the mud bar immediately below the canal, where it was thought further dredging might be necessary. A gravel bar at mouth of Big Creek is the only obstruction to navigation at the shoals.

SURVEY.

During July and August, 1895, office work upon maps and notes was continued, and preparations made to resume field work as soon as the water reached a low stage.

September 2–4 supplies, etc., were taken aboard the two quarter boats at Monroe, La., and the afternoon of the latter date the boats, in tow of the light-draft steamer *Le Vere*, left for Camden. Progress upstream was slow and difficult. A party which left Camden in skiffs September 4, to set gauges at intervals, was met at Jack's Island September 8 and taken aboard. The steamer was unable to pass Franklin Shoals, 53¾ miles below Camden, at the low stage of water, and left the quarter boats at that place September 9. The boats were cordelled 7 miles upstream to near Champagnolle, where organization was completed the night of September 11 by arrival of remainder of the party from Camden in skiffs.

Survey work was inaugurated September 12 at Champagnolle, except precise leveling, which extended to Eldorado Landing, 2 miles above. Field work was carried on under direction of Asst. Engineer T. C. Thomas, the general programme adopted having been as follows:

(*a*) A traverse or chain line running down the valley by the most direct practicable route, and touching the river at intervals, distances being double taped and angles in line determined by positive and negative repetitions. Azimuths carried by traverse line checked by frequent determinations of azimuth by observations on a circumpolar star near elongation. (*b*) Topography of river, including water line and top bank, cross sections of channel above water line at shoals, and topography of important tributaries for distances of 800 to 3,000 meters, according to size of stream. Also an approximate determination of overflow limits on either side of valley. (*c*) Hydrography of river, determined by cross-section soundings about every 400 meters in the pools and about every 100 meters on the shoals. (*d*) Precise levels, following traverse line in the main. (*e*) Ordinary levels, following river generally, checking stadia elevations, taking water surfaces at sounding ranges on shoals, connecting with high-water marks and old bench marks (1871 and 1873), and checking on precise levels at intervals. (*f*) Occasional discharge and sediment observations.

The plan outlined above was continued to Monroe, with one exception, the change introduced in October having been the closure of horizon at chain-line stations, and the carrying forward of azimuth with angles adjusted for horizon closure. It is apparent from the results obtained, even with this elaboration, that chain-line azimuths are not to be compared with those derived from tertiary triangulation, although, in this case, they were sufficiently close for practical purposes. To prevent accumulation of any considerable error, azimuth was directly observed more frequently than intended at first. A considerable part of the discrepancies found undoubtedly was due to errors in directly observed azimuths, it being doubtful if azimuths can be determined much closer than a minute (of arc) with the small transits used. The agreement between forward and back taping on chain line was surprisingly close, rarely approaching the limiting error (1:3,000) decided on at beginning of survey. In consequence, this limit was cut

down to 1:5,000. Several times the chain line and precise levels cut off considerable stretches of river by crossing through back country, and the stadia line and ordinary level closures over these stretches were uniformly satisfactory, those of the stadia line especially so.

After passing the overflow district the progress of topographical work was slower, on account of uneven banks. Below Ouachita City to Monroe the chain-line party passed through considerable open country, and, as a general thing, the precise-level party found good roads, so that branch of the work outstripped the rest and reached Monroe November 25. Several permanent reference points were established by the chain-line party at Monroe, and a number of street corners tied in. The precise-level party rested on precise bench mark 24 (Red River survey, 1889), but ran test levels to other benches to detect any changes of relative elevation. All, however, were found to have practically the same relative elevations as in 1893 and 1894. The precise-level party then was reorganized for topographical work, and in that capacity carried operations from Monroe up to a junction with the regular party.

While at Ouachita City three steel tapes were standardized by comparison with the 100-meter (+) steel tape of Red River survey.

In December work was continued from Monroe down to Sinope Landing, La., about 70 kilometers, where operations suspended on account of a rapid rise of the river. Chain line and soundings were carried down to Columbia, but as the ranges below Sinope were not located or leveled over, that stretch will have to be resounded. Precise-level work having discontinued at Monroe, a second stadia party was organized, which took topography of right bank, for a distance of 800 meters back from the river, from Monroe down. The wood line when lying outside of topography limits was sketched in. The hill line was located by compass and pedometer, except where it fell back to long distances from the river. Topography of left bank was sketched in, back to wood line, from Monroe to Sinope, the chain line having been used as a basis as far down as Cuba. Below Cuba to Sinope the chain line passed so far back from the river that the topography was taken by stadia, with same limits as on right bank. The chain line followed the Houston, Central Arkansas and Northern Division of the Missouri Pacific Railway from Monroe to within about 1 kilometer of the Riverton Bridge, and below that point it passed through the cleared country on left bank to Columbia. Progress was impeded the latter part of December by almost constant windy weather, which rendered instrumental work precarious and necessitated rerunning considerable stadia line. Operations were suspended at the close of the month, and the quarter boats towed to Monroe by the snag boat *Wagner*.

Field work was not resumed to end of the fiscal year for the reason that the period of continued low water usually sets in late in the summer and continues until the middle or latter part of December.

Since January 1, 1896, a portion of the field party has been retained in the office, employed in reducing field notes, the following work having been accomplished:

Index, page and subjective, of field notes; computation of latitudes and departures, meridional convergences and final azimuth, corrected for convergence, for the traverse line; final reduction of precise levels, Champagnolle to Monroe; reduction of ordinary (wye) levels, and adjustment of results for closures on precise levels; reduction of topographical levels, and adjustment of results for closures on ordinary levels; adjustment of topographical azimuths for closures on final azimuths of traverse line; collaboration of high and low water elevations determined by this and former surveys, and by the several permanent

gauges; reduction of observed elevations of water surface to low water of 1895; compilation of data for plotting profile of river, to show right and left top banks, bottom of channel, and high and low water lines; and replotting survey of 1871, for use when field work is resumed.

In order to resume field operations at the earliest practicable date the quarter boats are now being repaired at Monroe, La., and the field instruments and outfit put in order. It is of the first importance to close the gap in the precise levels between Frenchport and Champagnolle, and if the upper river should rise sufficiently the quarter boats will be towed to Camden and topography and hydrography begun at that point, the precise levels being sufficiently in advance. The present indications, however, are for an early and long low-water season, so that it may be necessary to resume at Sinope and push on to Red River. In that event the stretch between Camden and Champagnolle may have to wait till the following season. A beginning has been made on the tributaries, which will reduce expenses on that account. We have a map of about 60 kilometers of Bayou D'Arbonne on scale of 1:10,000, a reconnoissance map of Bœuf River on the same scale nearly finished, and maps and sketches of Bayou Bartholomew to be reduced to the same scale, and a number of precise-level benches convenient to each to serve as bases for a more careful survey. Saline River and Bayous Tensas and Maçon are the remaining chief tributaries of Ouachita River. These will require more work, as there are no maps of them extant. The recovery of quite a number of benches of 1873 between Camden and Columbia makes the work of that survey of no little value at each point found, and if we should meet with like good fortune on the run between Columbia and Trinity it may be possible to adjust the profiles of high and low water and of river bottom of the surveys of 1871 and of 1873 to Cairo datum, and use them with the corresponding work of the present survey. Discharge observations, especially at extreme stages, are of great importance, those at low water being essential to an estimate of the minimum water supply for a canalized river. The parties have been very successful in this respect, and it seems probable that they will be able to continue throughout the survey. High-water discharge observations are necessary for estimate of probable increase of the high-water limit due to dams, and consequently of the danger of overflow. There is no record of this class of work in the notes of the early surveys, and there has been no high water in Ouachita since the present survey began. The best that can be done, probably, will be to watch the gauge reports next spring and send out one or two parties to take discharge at the most convenient points at the time the crest of the spring flood is due. The development of levees on right bank of Mississippi River makes it probable that the extreme high-water marks of 1874 and 1882 will not be reached again in upper Ouachita, and if the system can be extended and maintained to the mouth of Red River, Ouachita River should be able to carry the waters of its own basin without danger to the people living on its banks.

Owing to the incomplete state of the survey it will be more satisfactory to postpone the publication of detailed results till the final report.

GENERAL REMARKS.

Ouachita River is a clear stream, the name corresponding to black water, and the line is marked where it joins Red River as distinctly as on Mississippi River at the mouth of Missouri or Ohio. Very much less drift runs at time of flood than in Red River, and the snags and obstructions generally are due to trees from sliding banks or sunken saw logs.

In addition to work by the snag boats at favorable times, great benefit would accrue from clearing the banks of both heavy timber and brush, especially at the points, the former to take weight off the banks and the latter to reduce the risks of collision in making the bends. This class of work is most economically done by large parties on quarter boats. Growth along river banks is very rapid, and should be cut well back, and the work repeated every few years. It is not advisable to equip the boats with steam power, for snags can not be handled except with strong appliances on snag boats, with good power and sufficient forecastle decks to carry quite a load. Explosives should be used even more liberally than heretofore.

The difficulties attending the survey are very great on so sensitive a stream, and the actual time in the field is limited not only by stage of river but by climatic conditions. The journals of the surveys of 1871 and 1873 show a large amount of sickness, and that of last year was not less marked. Every effort will be made to complete the work within a reasonable time, but work of the grade required can not be hastened, nor can it be done well by putting a large number of parties in the field, assuming it possible to obtain the class of men required. I may state that since I have had charge of this engineering district six assistants have died in the field or from the results of exposure to malarial influences, bad water, etc. The original estimate contemplated taking in all of the chief tributaries for which Congress had made appropriations, and treating them with Ouachita River as a system to be improved at the same time by a proper adjustment of locks and dams in the main river, should a system of slack-water navigation be found advisable. I am still of the opinion that this plan should be carried out, and therefore estimate accordingly.

Since the last report there has been a revival of interest in the subject of levees on Ouachita River, and the State engineers have made a beginning in restoring and enlarging the old levee about Charleston Plantation below Monroe, the work being nearly finished at the end of the fiscal year. Should the river be improved by locks and dams, it is probable that the United States will be called upon to do considerable of such work, and in any case it will be necessary to embank at places near pool level, which will necessitate more than ordinary care in determining the profile of bank top on both sides of the river. The main line of precise levels furnishes an excellent basis for levels for this purpose.

ESTIMATES.

Completing survey	$70,000
Quarter boats for chopping parties	5,000
Outfit, tools, and repairs	2,500
Expenses of snag boats	25,000
Expenses of chopping parties	10,000
Expenses of dredges	5,000
Administration, transportation, gauges, etc	2,500
Total	120,000

The amounts expended during the year and balances available July 1, 1896, are as follows:

Allotments.	Expended during year.	Balances July 1, 1896.
For general improvement, repairs, care of plant, etc	$5,675.23	$20,010.38
For survey	16,814.27	56,344.35
Total	22,489.50	76,354.73

Money statement.

July 1, 1895, balance unexpended	$28,844.23
Amount appropriated by act of June 3, 1896	70,000.00
	98,844.23
June 30, 1896, amount expended during fiscal year	22,489.50
July 1, 1896, balance unexpended	76,354.73
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	120,000.00

COMMERCIAL STATISTICS.

Navigation for regular packets during the fiscal year was reported to be as follows: From mouth of Black River to Harrisonburg, the entire year; to Monroe, La., from July 1 to August 15, 1895; and November 30, 1895, to June 1, 1896; and to Camden, Ark., from December 22, 1895, to April 27, 1896. The mouth of Red River was navigable the entire year.

List of steamboats engaged in the trade during the fiscal year.

Name.	Class.	Tonnage.	Length.	Breadth.	Depth.	Draft. Light.	Draft. Loaded.	Between—	Round trips.	Passengers.
			Feet.	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*			
Ouachita	Stern-wheel.	457.45	189	38	6.5	4 0	10 0	Monroe and New Orleans.	17	927
City of Camden	...do ..	299.23	175	35	5.5	2 2	5 6	New Orleans and—		
								Camden, Ark	15	
								Champagnolle, Ark	1	
								Pigeon Hill, Ark	1	
								Alabama Landing, La.	1	1,387
								Monroe, La	9	
								Harrisonburg, La.	10	
								Log Town, La	3	
Parlor City	...do ..	136.3	125	26	3.7	2 0	5 0	Monroe and Bœuf River.	11	20
								Monroe and Bayou Bartholomew.	3	.....
								Harrisonburg and New Orleans.	23	675
Belle D'Arbonne	...do ..	75.59	111	22	3.7	2 0	4 0	Monroe and New Orleans.	2	.....
								Monroe and Camden	26	47
Sterling White	Side-wheel.	117.09	120	30.5	4.2	2 6	4 6	Monroe and points on Upper Ouachita	28	160
								Monroe and Bayou Bartholomew.	30	140
								Monroe and Tensas River.	6	.....
Le Vere	Stern-wheel.	98.73	109.2	23.9	2.9	1 0	2 6	Monroe and Bayou Bartholomew.	1	.....
								Monroe to various points on Ouachita River.	7	15
Danube	...do ..	232.32	175	33.8	5.1	2 0	5 0	New Orleans and Tensas River.	4	.....
T. K. Green*	...do ..	32.77	81.8	17.3	3.1	1 4	3 0	Trinity and Bayou Dugdemona.	1	15
								Trinity and Little River.	38	
								Trinity and Tensas River.	88	
Stonewaret	...do ..	74.21	100	17	3	2 2	3 4	Camden and New Orleans.	2	.....
								Bœuf River and New Orleans.	1	.....
Flora Clarkt	...do ..	180.56	130	25.3	4.5	2 6	.....	Monroe and New Orleans.	1	.....
Geo. L. Basst	...do ..	53.82	91	21	3.3	.....	.....	New Orleans and points on Ouachita River.	1	.....

* With one or more barges. † Towboats.

List of steamboats engaged in the trade during the fiscal year—Continued.

Name.	Class.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Between—	Round trips.	Passengers.
						Light.	Loaded.			
			Feet.	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*			
E. H. Barmore*....	Stern-wheel.	171.47	135.7	30.1	5.4	2 6	5 0	Trinity and Tensas River.	7	.....
								Trinity and Little River.	6	.....
								Trinity and New Orleans.	1	.....
H. M. Townsend*..	...do ..	87.7	116.7	18	3.1	.....	.....	Camden and New Orleans.	1	.....
								Saline River and New Orleans.	1	.....
Lillie*	...do ..	61.42	120	26	3.5	2 6	3 6	Local towing, Trinity, Red River Landing, and Little River.	....	.....
Alvin.....	...do ..	201.55	143	29.1	7.1	.....	.....	Ouachita River and New Orleans.	1	.....
Albert Lea.....	Side-wheel.	24.47	64.48	12.3	4	2 6	4 0	Jonesville and Little River.	75	.....
								New Orleans and Monroe.	2	.....
Will Davis*	Stern-wheel.	75	100.8	23.6	3.6	1 8	2 2	New Orleans and Camden.	2	.....
								New Orleans and Bayou D'Arbonne.	1	.....
Rosa May.....	...do ..	16	80	14	2	0 8	3 0	Monroe and Bayou D'Arbonne.	6	.....
Dora†	Tug ..	3	33	9	5	3 0	4 6	U. S. mail boat, Jonesville and Tooley.	157	283
Cornelius†	...do ..	2.5	28	7	4	3 0	4 0	Irregular trips, Jonesville and Tooley.	....	.....
Cornie (gasoline) ..	Stern-wheel.	30	.....	.....	.....	0 8	3 0	Local towing, Monroe and bayous above.	....	.....
Walls (gasoline)...	...do ..	20	80	12	2	0 6	2 0	Monroe and Bayou D'Arbonne.	6	.....
Rosa B.....	...do ..	41.85	82.6	15.8	3	1 4	4 2	Local towing, Monroe and Bayou D'Arbonne.	....	.....
Skipper.....	Tug ..	5	32	6.5	3.5	1 8	2 0	Local towing at Monroe.	....	.....
Wayzata	...do ..	6	33	7	3.7	1 9	2 2	.....do	....	.....
Minnie	.....	.....	.....	.....	.....	.....	.....	No report	....	.....
Geo. W. Lyon.....	.....	.....	.....	.....	.....	.....	.....	.....do	....	.....
C. A. Hill.....	.....	.....	.....	.....	.....	.....	.....	.....do	....	.....
May Fisher.....	.....	.....	.....	.....	.....	.....	.....	.....do	....	.....
Walter Collier	.....	.....	.....	.....	.....	.....	.....	.....do	....	.....
Victor	.....	.....	.....	.....	.....	.....	.....	.....do	....	.....
Teal	.....	.....	.....	.....	.....	.....	.....	.....do	....	.....
Eva S.....	.....	.....	.....	.....	.....	.....	.....	.....do	....	.....

*Towboats. †With one or more barges.

Summary of commerce reported.

Articles.	1895–96.	1894–95.	1893–94.	1892–93.	1891–92.	1890–91.	1889–90.	1888–89.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons*	*Tons.*
Cotton.....	9,599	21,070	11,176	11,383	21,890	21,433	16,652	17,788
Cotton seed.....	4,706	6,005	3,645	4,423	5,577	6,593	5,058	2,660
Hides and skins..	68	166	72	4	7	25	36	23
Live stock.....	254	329	549	845	89	172	62	213
Lumber	1,080	218	262	18,000	461	16,388	7,951	5,963
Saw logs.....	49,000	10,000	28,257	28,000	26,880	120,000	50,000	.....
Staves.....	26,332	18,891	31,519	9,378	23,402	17,888	21,159	8,599
Rock	.....	.....	.....	.....	.....	18,000	.....	.....
Miscellaneous	7,112	5,660	6,572	5,251	5,197	10,856	783	1,096
Total down freights ..	98,151	62,339	82,052	77,284	83,503	211,355	101,701	36,342
Return freight....	19,866	11,340	13,808	11,157	18,317	27,842	40,766	24,228
Total	118,017	73,679	95,860	88,441	101,820	239,197	142,467	60,570
Estimated value..	$5,123,000	$3,293,000	$3,430,000	$4,466,000	$6,680,600	$9,130,000	$10,234,250	$8,798,000

Of the above freights the tributaries of Ouachita River contributed a total of 31,456 tons, valued at $977,000. The timber and stave interests showed a great increase in the past year, and it was estimated that 20,000 tons of logs were above Monroe June 30, 1896, awaiting a rise to float them down. The daily capacity of the sawmills at Monroe is 260,000 feet of lumber and 50,000 shingles; an increase of nearly 100 per cent in the past two years.

The following statistics, compiled from information furnished by the Camden Commercial League, show the resources of the country whose commerce, with uninterrupted navigation, could be made tributary to Ouachita River:

Population of territory affected (1895-96)	564,518
Annual cotton crop (estimated)..bales..	813,498
Estimated value	$32,539,920
Present freight rate per bale to Eastern Seaboard	$3.50
Freight saving on cotton, if water route were available	$1,550,000
Annual crop of cotton seed (estimated)..tons..	385,000
Estimated value	$4,000,000
Freight saving on cotton seed, if water route were available	$1,145,000
Lumber marketed last season..tons..	4,835,000
Value of lumber shipped last season	$82,700,000
Taxable property in district	$84,635,000
Amount of freight paid all lines of transportation	$17,815,000
Amount of business transacted	$197,895,000

The competing lines of transportation are as follows: Ouachita River is crossed by the St. Louis, Iron Mountain and Southern Railway at Arkadelphia, Ark.; by the St. Louis Southwestern Railway (Cotton Belt Route) at Camden, Ark., and by the Vicksburg, Shreveport and Pacific Railroad at Monroe, La. The St. Louis, Iron Mountain and Southern Railway has a branch line parallel to the river from Eldorado to Gurdon, Ark., and thence by the main line to Arkadelphia. A projected extension of this branch will give direct communication with the Mississippi River at Arkansas City, Ark., the part to be built being from Camden to Warren, Ark., a distance of about 50 miles. The Houston, Central Arkansas and Northern Railroad (another branch of the Missouri Pacific system) connects with Arkansas City at McGehee, 12 miles west, and thence runs in a southwesterly direction about midway between Bayou Bartholomew and Bœuf River, touches the Ouachita River, and crosses the Vicksburg, Shreveport and Pacific Railroad at Monroe, La., and continues down, parallel to the main river, to Columbia, La., crossing at Riverton, 4 miles above Columbia, and runs thence to Alexandria, La. The Natchez, Red River and Texas Railroad (narrow gauge) runs from Black River Station, opposite Trinity, to Vidalia, La., on Mississippi River opposite Natchez, Miss. The New Orleans and Northwestern Railway is completed from Natchez, Miss., to Bastrop, La., and crosses Tensas River near its mouth and Bœuf River about 2 miles north of Rayville, La. A railroad from Sunnyside, Chicot County, Ark., on Mississippi River, to Hamburg, Ark., crossing Bayou Bartholomew near Portland, is projected. The extension of the Kansas City, Watkins and Gulf Railway from Alexandria, La., to Natchez, Miss., has been begun, and will cross Black River about 7 miles below Trinity, La.

T 5.

IMPROVEMENT OF BAYOU BARTHOLOMEW, LOUISIANA AND ARKANSAS.

Bayou Bartholomew has its source in Jefferson County, southeastern Arkansas, within a few miles of Pine Bluff, and following a tortuous course, flows at first nearly parallel to Arkansas River, at a distance varying from 15 to 30 miles, then parallel to the Mississippi, at about the same average distance, but after entering Louisiana turns to the southwest and finally enters Ouachita River in Morehouse Parish, opposite Ouachita City. The total drainage area of the bayou and tributaries is about 1,800 square miles. The States of Louisiana and Arkansas made expenditures at various times for its improvement, navigation of the stream having been carried on to a considerable extent as early as 1843.

Examinations of the bayou were made in accordance with require-

ments of river and harbor acts as follows: From its mouth to the Arkansas State line, act of March 3, 1871; from Baxter, Ark., to its mouth, acts of June 18, 1878, and June 14, 1880, and above Baxter to the Lincoln County line, Arkansas, act of July 5, 1884. Reports upon these examinations are contained in reports of the Chief of Engineers, viz, 1872, pages 383–386; 1879, pages 997–1003; 1881, pages 1453–1457, and 1885, pages 1548–1552.

The project entered upon in 1881 contemplated cutting the leaning timber and the removal of snags, logs, wrecks, etc., to give safe navigation between the mouth and Baxter, Ark., about 150 miles above, at stages when steamboats could run. The cost of doing this work in two consecutive seasons was given at $26,862. In view of the appropriations made, and as new obstructions are added every year, no estimate for permanent improvement has been prepared.

The appropriations have been as follows:

By act of—		By act of—	
March 3, 1881	$8,000	July 13, 1892	$5,000
August 2, 1882	5,000	August 17, 1894	5,000
July 5, 1884	5,000	June 3, 1896	4,000
August 5, 1886	5,000		
August 11, 1888	5,000	Total	47,000
September 19, 1890	5,000		

The amount expended to June 30, 1895, was $38,110.03. Work commenced by hired labor in the summer of 1881 at Baxter, and July 20 to December 25 was carried down to Bartholomew, Ark. August 29 to December 1, 1882, it was resumed at Bartholomew and continued downstream to Lind Grove, La. In 1884 the contract method was given a trial, the work was let at $75 per mile, and November 10 to December 7 operations were carried from the mouth upstream 66⅔ miles. Work of the kind by contract having proved unsatisfactory and expensive, subsequent operations were conducted by hired labor. November 20, 1886, to January 20, 1887, work extended from the mouth upstream to Point Pleasant, La., and July 25 to September 10, 1887, the stretch above Point Pleasant to Poplar Bluff, Ark., was worked over. August 6 to November 21, 1889, work was carried from the mouth up to Oak Landing, and the following February the U. S. snag boat *Hooker* made a trip to Ohio Landing, Ark., removing jams of drift, etc. May 11 to August 14, 1891, operations were carried from Portland, Ark., about 35 miles below Baxter, to the mouth. August 1 to October 31, 1893, work extended from McComb Landing, Ark., about 30 miles below Baxter, considered the head of navigation, to the mouth. April 8–23, 1895, the U. S. snag boat *Wagner* worked from the mouth to Chemin en Haut Bayou, about 55 miles above, and although only seventeen months had elapsed since this part had been worked over at a low stage, it was found much obstructed by caved-in trees, side jams which had formed above them, floating butts, etc.

This intermittent work during a period of fourteen years benefited navigation to a considerable extent, rendering it comparatively safe at medium and high stages; but it was not so thorough as it should have been, on account of the necessity of distributing expenditures of small appropriations over long distances. Little was done in the stretch immediately below Baxter, as there was no immediate demand for navigation of that part of the bayou, and all interests were best served by applying the funds to the part of the stream in which boats ran. Before work by the United States commenced the average duration of the navigable season was about three months, and even for that short

period the passage was slow, difficult, and dangerous; fourteen days were required to make a trip to the head of navigation, boats having to cut leaning trees and remove jams and drift on the way. The work gave better navigation for about six months of the year, and enabled boats of double the capacity of those used formerly to make trips with comparative safety in half the time; and freight rates were said to be 50 per cent less.

Operations during the fiscal year ending June 30, 1896, were as follows:

For the purpose of removing snags, jams, or drift impeding navigation, the U. S. snag boat *O. G. Wagner*, Watkins Decker, master, made a trip over the bayou from its mouth to Portland, Ark., February 5–27, 1896. Jams were broken up and destroyed at Bonner Place, Alex. Arnett Landing, and Stokes Landing. All three were caused by large trees which had fallen across the channel. Floating butts were pulled aboard, cut into short lengths, and deposited out of the way.

The following is a summary of the work done, viz:

Snags removed from channel	82
Shore snags cut	2
Jams removed	3
Side jams removed	6
Leaning trees cut	2

This work left the channel of the bayou free of obstructions for the season of navigation, enabling boats to run without difficulty or delay.

As it was intended to put a chopping party at work in the upper part of the stream as soon as the water should fall to a low stage, the *Wagner* towed a quarter boat from Monroe, La., to Portland, Ark., to be ready when the low-water period set in. The water having reached a stage favorable for work, the party was organized at Portland May 21, 1896, under Overseer James R. Vaughan, commenced operations at McComb Landing, near mouth of Bearhouse Creek, the present head of navigation, and on June 30 had carried work downstream to within 2 miles of Parkdale, Ark., a distance estimated to be about 46 miles. The stage of water was very low, and effective work was done. The force of laborers was equipped with axes, saws, explosives, etc., and furnished with subsistence and shelter. Leaning timber was felled, cut into short lengths, and so disposed of as to dry out and not become snags in future. A number of dead trees, girdled some years ago, which had fallen into the bayou, were removed. Stumps within the banks and shore snags were cut close to the ground or blown up, and points, bends, and caving or sliding banks were well cleared of timber and brush. Snags, logs, trees, and stumps in the channel were hauled out on the banks and cut up whenever practicable, and those too heavy to be disposed of in this manner were destroyed with dynamite. In many places the channel was so obstructed by brush, logs, trees, limbs, and stumps embedded in the bottom that explosives had to be used freely to effect passageway for the light quarter boat used on the work.

The following is a summary of the work done by the chopping party May 22 to June 30, 1896, viz:

Channel snags cut and destroyed	4,293
Stumps cut and destroyed	1,043
Shore snags cut and destroyed	1,700
Logs cut and destroyed	2,729
Side jams removed	5
Leaning trees cut and destroyed	3,183
Trees girdled	26
Square yards willows and brush cut	1,904

This work was done thoroughly so far as it progressed, and will afford safe navigation for the present at stages on which boats can run. It is expected to continue operations down to the mouth as thoroughly as practicable with the means available, reserving an amount sufficient for a trip of one of the snag boats belonging to the district over the stream at the first high stage, to remove drift, etc.

Bayou Bartholomew is the largest tributary to the system of rivers forming the Ouachita Basin. The original project of 1880 contemplated removing the obstructions then existing by continuous thorough work in two successive seasons, at a cost of about $27,000, it being understood that small amounts would be needed from time to time for maintenance by the removal of new obstructions added each year. The limited and irregular appropriations made have prevented carrying out the work as planned, or any basis for estimates for completion and maintenance. The survey of Ouachita River now in progress will give information of this and other tributaries now lacking, and which could not be obtained with the small appropriations heretofore made, and until the completion of this survey it is not deemed advisable to make any modification of the existing project. The amount available is not sufficient for work above Bearhouse Creek nor for thorough work needed all the way below that point to the mouth; but there is little demand for navigation in the upper stretch at the present time.

Money statement.

July 1, 1895, balance unexpended	$4,889.97
Amount appropriated by act of June 3, 1896	4,000.00
	8,889.97
June 30, 1896, amount expended during fiscal year	3,303.32
July 1, 1896, balance unexpended	5,586.65
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	10,000.00

COMMERCIAL STATISTICS.

Bayou Bartholomew was reported navigable in the past fiscal year as follows: July, 1895, and January 1 to June 1, 1896.

List of steamboats engaged in navigation during the fiscal year.

Name.	Class.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Between—	Round trips.	Passengers.
						Light.	Loaded.			
			Feet.	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*			
Sterling White	Side-wheel.	117.09	120	30.5	4.2	2 0	4 6	Monroe, La., and mouth of Bearhouse Creek, Arkansas.	30	140
Parlor City	Stern-wheel.	136.3	125	26	3.7	2 0	5 0	Monroe and Lind Grove, La.	3	....
Le Vere.....	....do .	98.73	109.2	23.9	2.9	1 0	2 6	Monroe, La., and Portland, Ark.	1	....

NOTE.—In addition to above, three 800-ton barges, drawing 8½ feet loaded, made 1 trip from the bayou to New Orleans.

Summary of commerce reported.

Articles.	1895–96.	1894–95.	1893–94.	1892–93.	1891–92.	1890–91.	1889–90.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Cotton	1,235	1,390	2,434	1,000	2,372	3,971	2,000
Cotton seed	270	3,826	2,991	1,300	3,326	2,467	4,000
Cotton-seed meal	.....	.....	.....	.....	1,425	516	.....
Saw logs	7,683	.....	159	2,000	4,450	20,080	11,839
Staves	6,012	117	2,569	2,375	1,648	17,822	.....
Miscellaneous	350	100	665	175	410	1,340	.....
Total down freight	15,550	5,433	8,818	6,850	13,631	46,196	17,839
Return freight	2,110	1,200	3,469	825	1,534	3,103	4,000
Total	17,660	6,633	12,287	7,675	15,165	49,299	21,839
Estimated value	$561,000	$243,000	$564,000	$136,000	$515,000	$826,000	$492,700

The logging and stave interests during the past season showed the greatest activity seen in many years.

This stream is crossed at Baxter, Ark., the upper limit of improvement, by a branch of the St. Louis, Iron Mountain and Southern Railroad, which connects with the Mississippi River at Arkansas City, Ark., runs west 56 miles to Warren, Ark., and probably will be extended to Camden, on the Ouachita, which is connected with the main line by a branch to Gurdon, Ark. The Houston, Central Arkansas and Northern Railroad (another branch of the Missouri Pacific system) runs parallel to Bartholomew from McGehee, Ark., to Monroe, La. The New Orleans and Northwestern Railway has been completed to near Bastrop, La., and crosses the Houston, Central Arkansas and Northern Railroad at Kellers, La., 7 miles south of Bastrop. A new line from Sunnyside Landing, Ark., on the Mississippi River, to Hamburg, Ark., crossing Bayou Bartholomew near Portland, Ark., is projected.

T 6.

IMPROVEMENT OF BŒUF RIVER, LOUISIANA.

Bœuf River has its source in Chicot County, southeastern Arkansas, flows in a general southwesterly direction, and enters Ouachita River opposite Stafford Point, 8 miles above Harrisonburg, Catahoula Parish, La. It has been considered a navigable stream for more than half a century, the report of the Louisiana board of public works for 1840 stating that it had been opened to Point Jefferson.

In accordance with requirement of river and harbor act of June 14, 1880, an examination of the river was made the latter part of that year. It was found to be navigable at high water to Point Jefferson, but the passage difficult and dangerous on account of snags, logs, and leaning timber. The project based upon this examination contemplated the removal of these obstructions to afford reasonably safe navigation to Wallace Landing, about 19 miles above Point Jefferson, for light draft boats during the period of high water, or for about five months of the year. The estimates contemplated operations during two consecutive seasons, at a cost of $20,000. (Report Chief of Engineers, 1881, pp. 1424–1428.) The small and intermittent appropriations, and the addition of new obstructions each year, increased the cost and prevented thorough work and its completion as planned. The distance from Wallace Landing to the mouth, as scaled from the maps, is about 152 miles.

Under river and harbor act of July 5, 1884, an examination was made of three outlets near Point Jefferson, and their closure recommended

as necessary to preserve navigation of the stream. (Report Chief of Engineers, 1885, pp. 1545–1548.) This addition to the project was made by act of 1886, which provided for closing Outlet No. 1.

The following appropriations have been made:

By act of—		By act of—	
March 3, 1881	$5,000	July 13, 1892	$10,000
August 2, 1882	5,000	August 17, 1894	8,000
July 5, 1884	5,000	June 3, 1896	6,000
August 5, 1886	5,000		
August 11, 1888	6,000	Total	55,000
September 19, 1890	5,000		

The amount expended to June 30, 1895, was $43,293.30. The improvement commenced, by hired labor, in 1881, and August–November of that year work of a chopping party was carried from Point Jefferson downstream about 100 miles, when the funds ran out. September–December, 1882, the stretch between the railroad bridge near Girard and Point Jefferson was worked over. With the appropriation of 1884 the contract method was given a trial. The work was let at $75 per mile, and carried from the mouth upstream 60 miles, November–December, 1884. Work of the kind by contract having failed to prove satisfactory or economical, subsequent operations were conducted by hired labor. The act of 1886 provided for continuing the improvement and closing Outlet No. 1, but it was found essential that all three outlets be closed at the same time. By uniting with the planters whose lands would be protected, this was done in 1887–88, the proportion of cost borne by the United States having been $5,441.78. November, 1888, to May, 1889, work for the removal of obstructions was carried from Point Jefferson to the mouth. In December, 1889, the small balance available was expended for operations of the light snag boat *Hooker* over the lower 60 miles. September–December, 1891, work was carried from the mouth to a point about 10 miles above the railroad bridge near Girard, and November, 1893, to January, 1894, the same stretch was worked over again. September, 1894, to June, 1895, operations extended from the railroad bridge near Girard to Wallace Landing, and thence down to Crosby Place, about 63 miles above the mouth, where they were suspended temporarily by a rise.

This work put the river in good condition so far as the removal of snags, leaning timber, etc., could afford. Steamboats could navigate safely at any stage high enough to permit them to cross the bars, saving at least thirty-six hours' time on the round trip.

Operations during the fiscal year ending June 30, 1896, were as follows:

The water having fallen to a favorable stage, operations were resumed July 8 at Crosby Place, and between that date and September 3, 1895, were carried down to the mouth. The work was done under supervision of Overseer J. R. Vaughan, and consisted of the removal of trees, stumps, logs, brush, channel and shore snags. The timber was cut or girdled as found necessary, and logs, stumps, and snags that could not be cut were destroyed with explosives. In the crooked reaches points and bends and towheads were cleared. At Duffy Bend a slide containing 35 large trees and many smaller ones was removed, and a number of lesser slides were removed on the way down; two bad side jams were removed, one below Eagle Creek and the other at Dailey Landing; 450 trees and 425 square yards of brush were cleared from an island at Three Rivers, and 3 small tow-heads below Dailey Landing were cleared of brush and logs. All the work was done thoroughly, and no obstructions dangerous to navigation were allowed to remain.

The following is a summary of the work done July 8 to September 3, 1895, viz:

Channel snags cut and destroyed	1,370
Shore snags cut and destroyed	1,500
Stumps cut and destroyed	1,330
Logs cut and destroyed	3,185
Side jams removed	3
Leaning trees cut and destroyed	5,278
Trees girdled	7,734
Square yards of willows and brush cut	13,414

The U. S. snag boat *O. G. Wagner*, Watkins Decker, master, was sent into Bœuf River in March, 1896, to supplement the work of the chopping party by the removal of drift, wrack heaps, floating butts, etc. The *Wagner* left Monroe, La., March 6, entered Bœuf River and commenced work March 9, which was carried upstream to within 4 miles of Wallace Landing. The boat returned to the mouth March 29, and thence to Monroe March 30, 31. Floating butts were pulled out, cut into short lengths, and the pieces deposited in pockets close in shore. Side jams, caused by trees breaking down, their tops catching drift, were removed and the drift started downstream. Two jams were broken up near Winters Place, both caused by large trees falling across the channel. With these exceptions, the master of the *Wagner* reported he found the river in good navigable condition.

The following is a summary of the work done by the *Wagner:*

Snags pulled	150
Shore snags cut	7
Jams removed	2
Side jams removed	19

The work of the last two years was done thoroughly, and practically completes the project of 1880 for benefiting high-water navigation. It will not be permanent, however, on account of obstructions added by drift from above Wallace Landing, floods, sliding banks, and the rapid growth of vegetation along an alluvial stream. The expenditure of about $2,500 a year for keeping the channel clear of obstructions and maintaining safe navigation at high stages would appear to be warranted by present commerce; or, better still, a permanent appropriation for snagging operations, etc., in Ouachita River and its chief tributaries. If no provision is made for maintenance, the river soon will return to its former obstructed condition, and the funds spent, to a great extent, will have been wasted.

The closure of the three outlets near Point Jefferson, completed in 1888 as substantially as the funds available permitted, gave immediate benefit to navigation by confining the flow to its natural course and scouring the bars in the channel below, but during the overflow from Mississippi River in the spring of 1890, caused by breaks in the Arkansas levees near the headwaters of Bœuf River, all the dams were destroyed. Channel soundings in March, 1896, showed depths varying from 8 to 11 meters in the stretch of river immediately above the outlets, but only 2.5 to 3.2 for the stretch below them. As it is essential that all three outlets be closed substantially and at the same time, and as sufficient funds for the purpose have not been available at any time since the dams were destroyed, the work has been deferred until a specific appropriation should be made for the purpose. The cost is estimated at $30,000. (See Report Chief of Engineers, 1893, p. 2017.)

Assistant Engineer T. C. Thomas made a reconnoissance of Bœuf River on the snag boat *Wagner* in March, 1896, the report upon which is appended.

Money statement.

July 1, 1895, balance unexpended	$5,706.70
Amount appropriated by act of June 3, 1896	6,000.00
	11,706.70
June 30, 1896, amount expended during fiscal year	3,141.32
July 1, 1895, balance unexpended	8,565.38
Amount (estimated) required for completion of existing project	24,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	24,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

REPORT OF MR. T. C. THOMAS, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., April 1, 1896.

MAJOR: I have the honor to submit report on a reconnoissance of Bœuf River, made March 23–29, current year:

Joined U. S. snag boat *Wagner*, Watkins Decker, master, at Girard, La., in evening of March 19. *Wagner* continued upstream, snagging on the way, to within about 8 kilometers of Wallace Ferry (224 kilometers from the mouth of river). Turned here in evening of March 23 and ran for mouth of river, reaching that point in evening of March 29. During down trip the river was sketched by plane-table method. Table was oriented by compass; distances along river were approximated by relays of men pacing a base of 25 meters laid off on steamer deck, each man walking back along the base at such a rate as to keep in range with two objects (trees generally) on shore.

In the lower and unsettled portions of the river, where little was to be sketched beyond the banks, boat was run at a higher speed, and distances determined by timing boat, the speed having been determined by pacing (rapidly) as before. Boundary lines of clearings were sketched and houses roughly located. Height of banks above water surface estimated; vertical distances being laid off on side of boat from water surface up, as an aid in this respect. Longitudinal soundings were taken over well-known shoals, and the low-water depths over such shoals, when ascertainable, were noted on sketch. Cross sections made of river and Outlet No. 1 at Point Jefferson, and of river at the New Orleans and Northwestern and the Vicksburg, Shreveport and Pacific Railroad bridges. Several stops were made for collecting information as to cotton, etc., produced in the country adjacent, and data relative to high-water marks and overflows. Such authentic high-water marks as could be found were referred by levels to benches established on trees in the neighborhood of such marks. Levels also were run from the precise level bench at Girard to the Weather Bureau gauge in Bœuf River at the Vicksburg, Shreveport and Pacific Railroad Bridge, and from the precise level bench at Stafford Point to water surface at mouth of Bœuf River.

The river banks generally have good slopes, with no evidences of recent caving. The clear waterway varies in width from about 40 meters in the upper river to 75 meters near the mouth. There is little or no leaning timber; no channel snags showing at the stage prevailing during the down trip, and no wrack heaps of moment in the river proper. The bed of the river is said to be remarkably free from logs.

The outlet at Point Jefferson is a serious injury to the river. Channel soundings taken during present reconnoissance show depths varying from 8 meters to 11 meters for the stretch immediately above the outlet, and from 2.5 meters to 3.2 meters for stretch immediately below. Cross sections of outlet and of river above and below are appended.

The following table shows low-water depths over the principal shoal stretches and bars:

Locality.	Depth found.*	Low-water depth.	Character of bottom.
	Meters.	*Meters.*	
Point Jefferson to Mound Landing (2.5 kilometers)	2.5 to 3.2	0.2	Gravel.
Lower end of Old River between Brinson and Ray Place	3	.3	Do.
Lower end of White Island	.....	.3	Do.
Mays Bar	3 to 3.1	.4	Do.
Three Rivers	.....	.6	Do.
200 meters below Mason Ferry	.....	.2	Sand.
Turkey Creek to mouth of Bœuf (5.3 kilometers), average	.....	.3	
Mouth of Bœuf	.....	.2	Do.

*At a stage about 2.7 meters (9 feet) above low water.

Bœuf River could be navigated at medium stages for a considerable distance above Point Jefferson. That boats have not gone far above this point probably is due to the fact that the upper country is wild and unsettled and offers nothing for shipment except staves. On the stage prevailing during present reconnoissance the *Stoneware* brought down from above Point Jefferson stave barges loaded to 6½ feet draft.

The following tributaries of the Bœuf have been navigated by small steamboats or by tugs with barges: Bonne Idee to Hefner's warehouse, 10 kilometers; Big Creek to Hewitt's Gin, 6 kilometers; Turkey Creek for a short distance, and Deer Creek up to the New Orleans and Northwestern Railroad Bridge. Outlet No. 1, at Point Jefferson, has been navigated to Eason's Ferry, 20 kilometers.

The connections with the water surface at the Vicksburg, Shreveport and Pacific Railroad Bridge and at mouth of river indicate a fall of 5. 66 meters in 175 kilometers of river; the stage at Vicksburg, Shreveport and Pacific Bridge being about 2.7 meters (9 feet) above low water, and at mouth of river about 10.5 meters. The fall for high water of 1892 between same limits was 4.84 meters.

During the up trip of the *Wagner* the water was backed up Bœuf River as far as Hebert's Place, 83 kilometers from the mouth, the stage in Ouachita River being about 11.2 meters above low water (March 11).

During the downward trip, however, when the Ouachita had fallen about 0.7 meter, there was a moderate current in Bœuf River down to the mouth.

The main banks on the front are nearly at elevation of high water, from Point Jefferson to Bird Lake Landing, varying from a little above to a little below. Below Bird Lake the banks drop rapidly, and at the mouth of Big Creek the high-water marks indicate that banks are overflowed to a depth of about 4 meters. These low banks are the rule from Big Creek to a short distance below Turkey Creek; they were, to a great extent, under water during the present reconnoissance. From near Turkey Creek to mouth of river the banks are somewhat higher, but are overflowed at high stages of the river. On the left bank, however, from Gum Point Landing to the mouth, are occasional stretches of high bank only slightly below high-water line. In the neighborhood of Point Jefferson the banks drop rapidly to swamp on the back, leaving a comparatively narrow strip of ground above overflow. From Girard to Harland Field the high ground extends several miles back, in the general case, reaching to the La Fourche Swamp on the right and the swamps of Big Creek on the left. The country back of Alto Landing, left bank, is a succession of swales and ridges, the latter above overflow.

The highest known water on Bœuf was that of 1882. The other noted high-water years were 1876 and 1892; 1876 was about 0.13 meter and 1892 0.10 meter below 1882 at Alto Landing. The relation was quite different, however, in other localities; thus, at Charlieville high water of 1892 was 0.44 meter below that of 1882. No levees were seen except the remains of that near Point Jefferson, built for closing the outlets into Lake La Fourche.

The greater part of the land above high-water line, or subject to occasional overflow only, is cleared. Some of the country has been in cultivation for many years and does not yield well without fertilizers, but the greater part is fresh and productive. A section of country called Egypt, cornering on the river at Harland Field is said to be specially fertile.

Bœuf Prairie parallels river from Gum Point Landing to Turkey Creek at a distance of 1 to 3 kilometers out from left bank. The greater part of prairie is subject to occasional overflow. It has a rich soil and is well settled.

Following is an estimate of the cotton and cotton seed produced in the neighborhood of the localities named, and which probably would be shipped by boats if Bœuf River were navigable during the shipping season:

Locality.	Cotton.	Cotton seed.	Locality.	Cotton.	Cotton seed.
	Bales.	*Tons.*		*Bales.*	*Tons.*
Left bank from Mound Landing to Jordan Place (opposite Balfour)	150	.....	Boykin	100	50
Tillman Landing	700	300	Guill	200	100
Meyrick Island	100	.....	Alto Landing	2,000	1,000
Ellwood	350	.....	Harland Field	1,000	500
McCaskill	800	400	Bluff Gin	1,000	.....
Mhoon's	2,000	600	Charlieville	1,000	350
Alexander	400	200	Frank Hatch	1,000	.....
			Total	10,800	3,500

The above should not be taken as a complete statement of the output of the country tributary to the river. Large quantities of staves are produced above Point Jefferson, and considerable quantities at points farther down. Cattle and hogs are raised extensively along the upper river, and again on the lower river from Bird

Lake Landing to the mouth. Bœuf Prairie also produces large quantities of live stock. Under present conditions the boating season on the Bœuf generally opens too late to move much of the cotton crop. Cotton is shipped principally by the Vicksburg, Shreveport and Pacific and New Orleans and Northwestern railroads. Some is hauled from the Frank Hatch neighborhood to Bosco Station on the Houston, Central Arkansas and Northern Railroad. Of late years the cotton shipped by boat generally is carried to the Vicksburg, Shreveport and Pacific Railroad Bridge, near Girard, and shipped thence by rail. Cattle raised in the lower country are driven to Monroe in large numbers, and fattened for the Northern market.

Very respectfully, your obedient servant,

T. C. THOMAS, *Assistant Engineer.*

Maj. J. H. WILLARD,
Corps of Engineers, U. S. A.

COMMERCIAL STATISTICS.

In the past fiscal year Bœuf River was reported navigable from July 1 to 15, 1895, and January 1 to April 30, 1896.

List of steamboats engaged in navigation in the fiscal year.

Name.	Class.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Between—	Round trips.	Passengers.
						Light.	Loaded.			
			Feet.	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*			
Parlor City.....	Stern-wheel.	136.30	125	26	3.7	2 0	5 0	Monroe and various points below Vicksburg, Shreveport and Pacific R. R. Bridge.	11	20
Stoneware*.....	....do ..	74.21	100	17	3	2 2	3 4	New Orleans and above Point Jefferson.	1	...
Flora Clark*.....	....do ..	180.56	130	25.3	4.5	2 5	.....	New Orleans and Bœuf River.	1	...
Julia H†.....	Tug ...	4.90	.....	.....	.....	3 0	3 6	Starts Landing and Alto.	6	...
								Starts and Spann landings.	20	...
Irwin†.....	Launch	3	35	8	.....	2 6	3 2	Stafford Point to landings from Point Jefferson down.	76	...

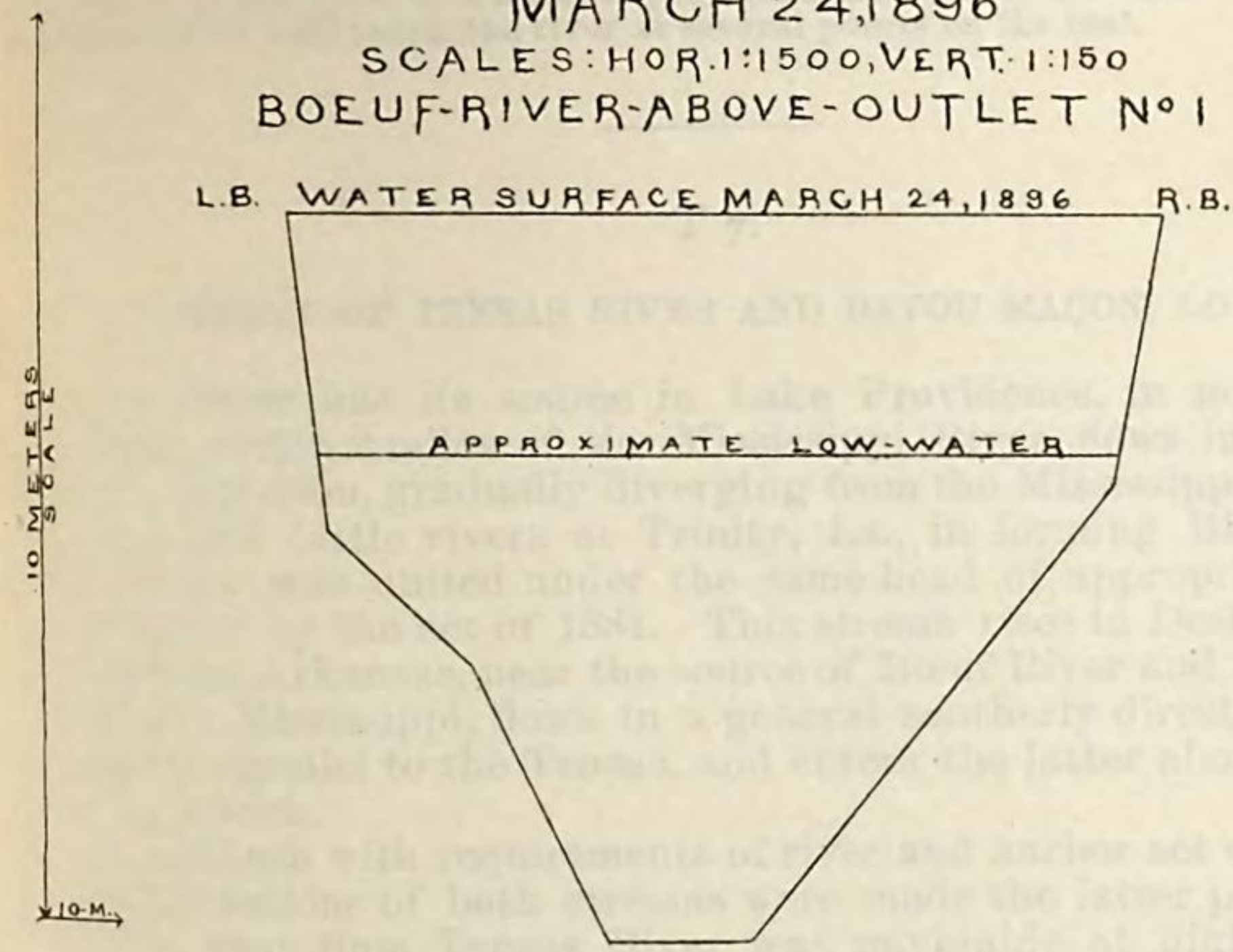
* Towboats. † With barges.

Summary of commerce reported.

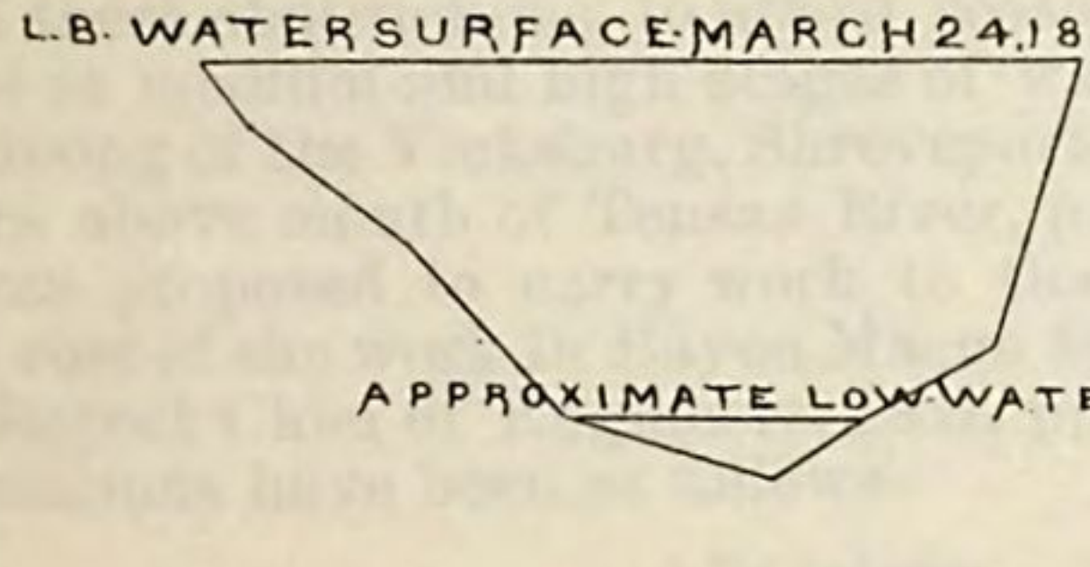
Articles.	1895–96.	1894–95.	1893–94.	1892–93.	1891–92.	1890–91.	1889–90.	1888–89.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Cotton.....	707	876	900	626	1,583	1,760	1,397	1,084
Cotton seed.....	1,633	2,313	2,550	1,878	1,178	716	731	834
Hides and skins...	8	1	.....	.....	50	.....	.....	.....
Live stock.....	64	76	12	.....	19	.....	.....	.....
Lumber	1,100	75	300	250	1,352	.....	.....	.....
Saw logs.....	840	.....	.....	.....	1,223	.....	.....	.....
Staves.....	4,000	1,389	4,626	923	3,138	1,777	263	54
Miscellaneous	190	136	450	300	72	179	.....	91
Total down freight	8,542	4,866	8,838	3,977	8,615	4,432	2,391	2,063
Return freight.....	425	250	650	335	1,370	3,458	1,594	1,376
Total	8,967	5,116	9,488	4,312	9,985	7,890	3,985	3,439
Estimated value...	$270,000	$159,000	$350,000	$200,000	$501,000	$636,500	$580,850	$457,100

CROSS SECTIONS AT POINT JEFFERSON, LA.
MARCH 24, 1896
SCALES: HOR. 1:1500, VERT. 1:150

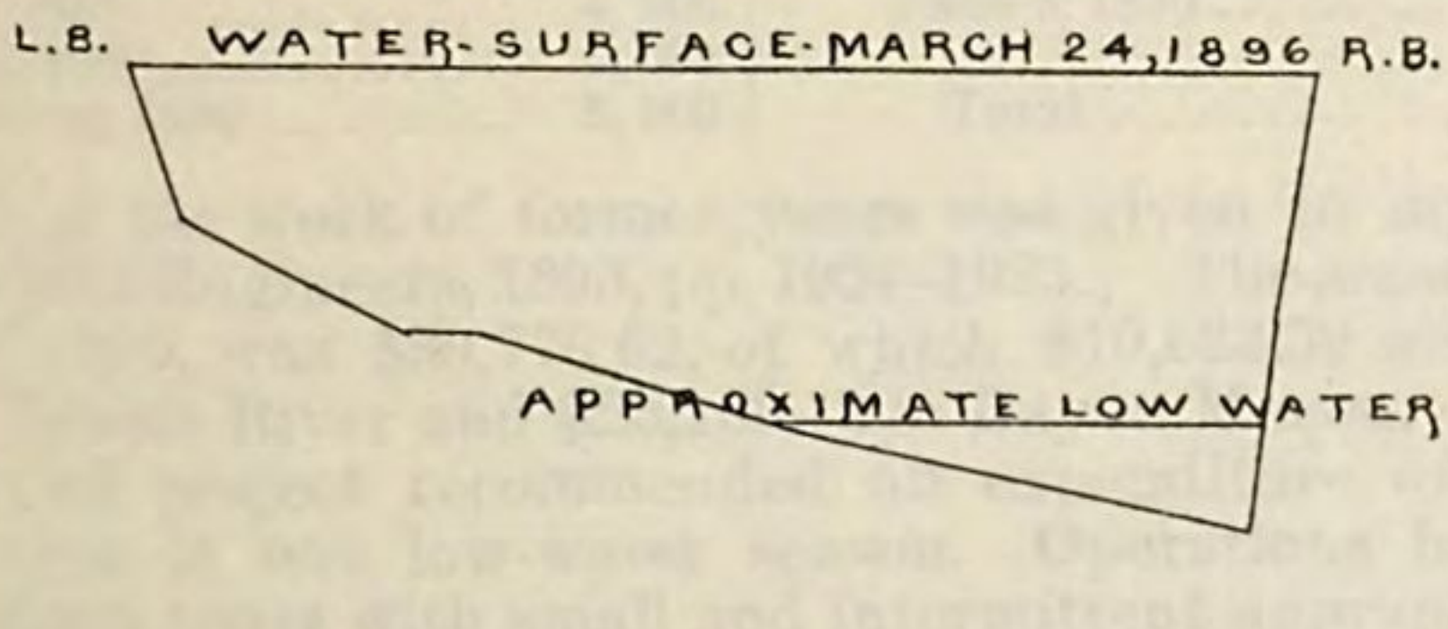
BOEUF-RIVER-ABOVE-OUTLET Nº 1



BOEUF-RIVER- BELOW-OUTLET Nº 1

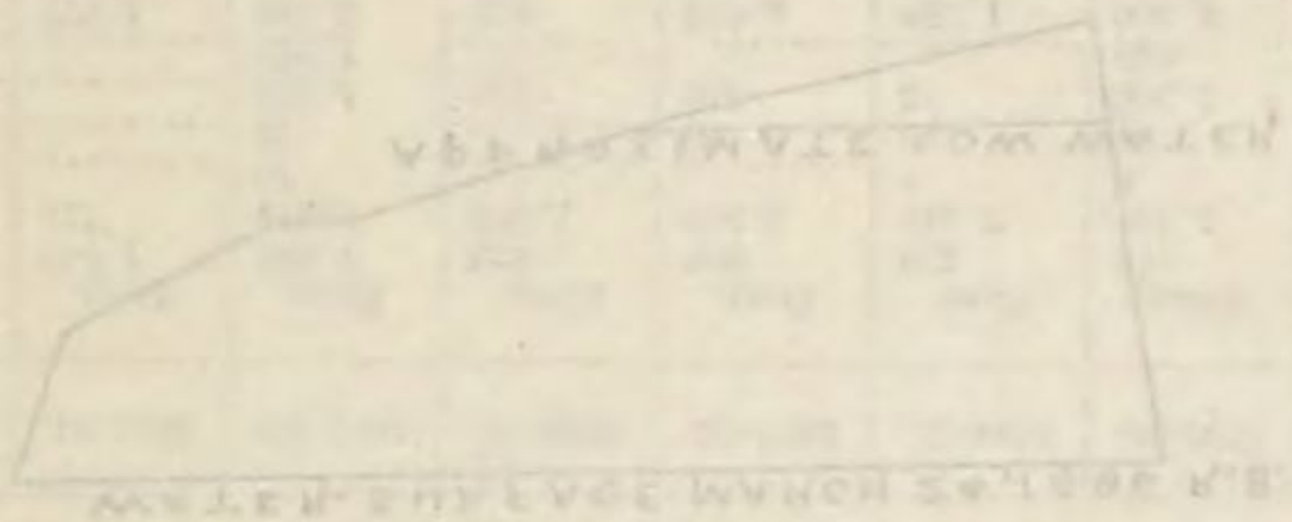


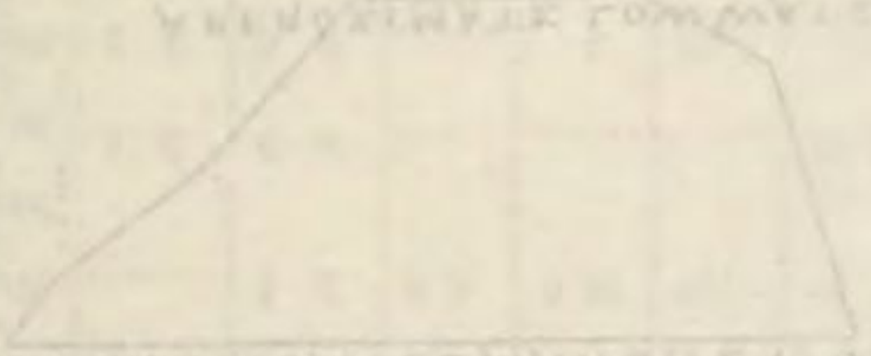
OUTLET Nº 1

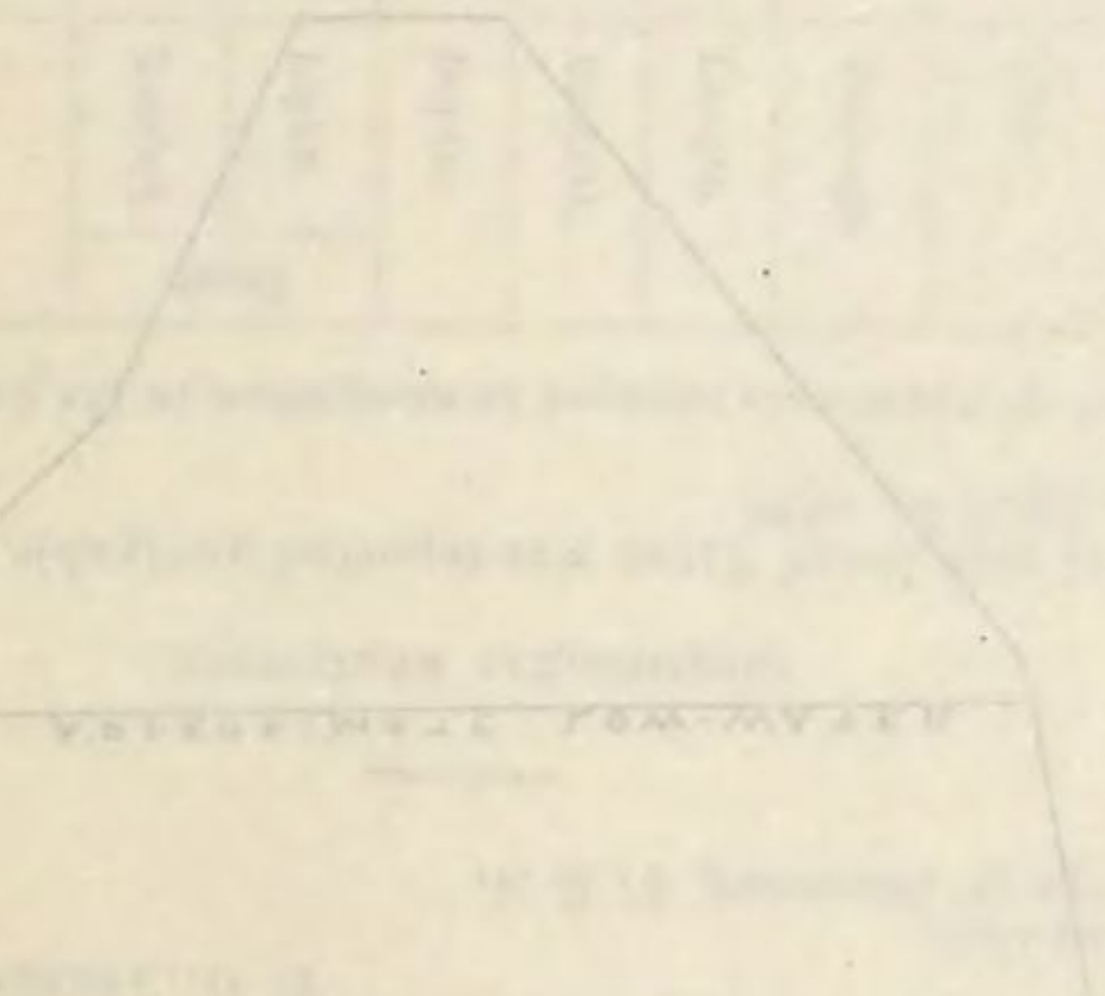


ANDREW B. GRAHAM, PHOTO-LITHO WASHINGTON, D.C.

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The Vicksburg, Shreveport and Pacific Railroad crosses Bœuf River near Girard, La., and the New Orleans and Northwestern Railway crosses about 2 miles north of Rayville, La. The Houston, Central Arkansas and Northern Railroad runs parallel to the river on the west, and a line is projected (Louisiana, Arkansas and Missouri Railroad) which will touch the river at several points on the east.

T 7.

IMPROVEMENT OF TENSAS RIVER AND BAYOU MAÇON, LOUISIANA.

Tensas River has its source in Lake Providence, in northeastern Louisiana, within 2 miles of the Mississippi River, flows in a general southerly direction, gradually diverging from the Mississippi, and joins Ouachita and Little rivers at Trinity, La., in forming Black River. Bayou Maçon was united under the same head of appropriation with Tensas River by the act of 1884. This stream rises in Desha County, southeastern Arkansas, near the source of Bœuf River and a few miles west of the Mississippi, flows in a general southerly direction west of and nearly parallel to the Tensas, and enters the latter about 40 miles above its mouth.

In accordance with requirements of river and harbor act of June 14, 1880, examinations of both streams were made the latter part of that year. At that time Tensas River was navigable at high water to Westwood Place, about 75 miles above its mouth, and boats ran in Bayou Maçon about 98 miles to Floyd. Navigation of both streams was difficult and dangerous, on account of leaning timber and snags, logs, etc., in the channel. The project contemplated one season's work for removal of these obstructions, to afford reasonably safe navigation for small boats at medium and high stages of water. As boats ran to Dallas, the crossing of the Vicksburg, Shreveport and Pacific Railroad, about 134 miles above mouth of Tensas River, prior to the war of the rebellion, it was proposed to carry work to that point, at a cost of $23,000. The cost of the work in Bayou Maçon to Floyd was estimated at $17,000. (Report Chief of Engineers, 1881, pp. 1457–1467.)

The appropriations have been as follows:

By act of—		By act of—	
March 3, 1881	$3,000	July 13, 1892	$5,000
July 5, 1884	4,000	August 17, 1894	5,000
August 5, 1886	4,000	June 3, 1896	5,000
August 11, 1888	5,000		
September 19, 1890	5,000	Total	36,000

A résumé of the work of former years was given in my last report. (Report Chief of Engineers, 1895, pp. 1924–1925.) The amount expended to June 30, 1895, was $30,776.62, of which $10,623.50 were applied to improving Tensas River and $20,153.12 to Bayou Maçon.

The original project recommended an expenditure of $40,000 for thorough work in one low-water season. Operations have dragged along for fifteen years with small and intermittent appropriations, permitting removal of the worst obstructions only from time to time. The last work, September, 1894 to January, 1895, put Bayou Maçon below Floyd and Tensas River below Westwood Place in fairly good navigable condition for the time. Drift brought down by floods, caving and sliding banks, and the rapid growth of timber and brush add obstructions every year, which should be removed in the interest of safe navigation.

For works of this class it would be a measure of economy to provide a liberal sum to free the channel of snags and logs and clear the banks for some distance back, thereby lessening the source of obstructions. The work once thoroughly done could be maintained by small expenditures from time to time, and for the latter purpose a permanent provision for snagging operations in Ouachita River and its principal tributaries probably would be the most advantageous method.

With the small balance available, operations could not be resumed during the fiscal year.

Request having been made for removal, during the period of low water, of débris of wreck of steamer *H. J. Dickey*, sunk January, 1891, in Bayou Maçon a few miles above Delhi, Watkins Decker, master U. S. snag boat *Wagner*, was directed to destroy the reported obstruction with explosives. This was done December 3, 1895, the master of the snag boat reporting as follows:

I found the water in Bayou Maçon very low, the gauge at the railroad bridge reading 1 foot below zero. At the wreck I found a piece of one guard, about 40 feet long, lying along the right bank and the shaft lying across the channel with its flanges about 3 inches above water. I placed four charges of dynamite about 10 feet apart under the piece of guard and destroyed it. I then put collars of dynamite around the shaft close to the flanges to break them off and, if possible, to break the shaft in two. The flanges were destroyed, but the shaft remained unbroken. I then placed charges at intervals of 6 to 8 feet under the shaft and when they were exploded, the trash and sand being blown out, allowed the shaft to sink until there was 2 feet of water over it. One hundred pounds of Atlas powder, 60 per cent nitroglycerin, were used in destroying the wreck, and I can safely say that at no time when there is navigable water in Bayou Maçon, even for a flatboat, will it be an obstruction. When the bottom of the bayou shall have been cleared of all snags and logs and made as clean as the bottom of a canal, then only will any portion of the wreck have to be removed.

Having 50 pounds of Atlas powder left after destroying the wreck, I expended it destroying 11 logs, 1 stump, and 1 jam at the Vicksburg, Shreveport and Pacific Railroad Bridge near Delhi. The jam was caused by stave men putting logs across the draw to catch staves as they were floating down the bayou.

The cost of destroying the wreck and doing the work at the railroad bridge was $77.08.

Money statement.

July 1, 1895, balance unexpended	$223.38
Amount appropriated by act of June 3, 1896	5,000.00
	5,223.38
June 30, 1896, amount expended during fiscal year	77.08
July 1, 1896, balance unexpended	5,146.30
Amount (estimated) required for completion of existing project	4,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	4,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

COMMERCIAL STATISTICS.

The river and bayou were reported navigable in the fiscal year, as follows: On Tensas, Jordan was head of high-water navigation, January 15 to May 30, 1896; Kirk Ferry was head of low-water navigation. On Bayou Maçon, Floyd was head of high-water navigation, February 1 to May 30, 1896; Como Landing was head of low-water navigation.

List of stern-wheel steamboats reported navigating Tensas River and Bayou Maçon in the fiscal year 1896.

Name.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Between—	Round trips.
					Light.	Loaded.		
		Feet.	*Feet.*	*Feet.*	*Ft.In.*	*Ft.In.*		
T. K. Green	32.77	81.8	17.3	3.1	1 0	3 0	Trinity and New Light	8
							Trinity and Kirk Ferry	30
							Kirk Ferry and New Orleans and Northwestern R. R. Bridge.	16
Le Vere	98.73	109.2	23.9	2.9	7	2 10	Monroe, Floyd, and Vicksburg, Shreveport and Pacific R. R. Bridge.	6
Danube	232.32	175	33.8	5.1	2 0	5 0	New Orleans, Tensas River and Bayou Maçon.	4
Teal	.....	.....	.....	.....	.....	.....	No report	....
Eva S.	.....	.....	.....	.....	.....	.....	do	....

Summary of commerce reported.

Articles.	1895–96.	1894–95.	1893–94.	1892–93.	1891–92.	1890–91.	1889–90.	1888–89.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Cotton	1,038	1,543	450	498	3,762	2,760	1,527	2,750
Cotton seed	2,444	2,993	1,400	1,457	4,876	4,850	2,920	4,000
Hides and skins	.....	50	2	3	.....	10	2	5
Live stock	.....	290	108	3	10	6	.....	225
Staves	285	260	895	26	71	1,032	3,325	3,500
Lumber	640	4,012	300	.....	440	.....	.....	.....
Miscellaneous	150	1,045	104	.....	1,942	378	50	1,823
Total down freight	4,557	10,193	3,259	1,987	11,101	9,036	7,824	12,303
Return freight	272	2,092	2,700	662	5,886	6,000	5,216	8,202
Total	4,829	12,285	5,959	2,649	16,987	15,036	13,040	20,505
Estimated value	$146,000	$561,000	$389,000	$122,500	$990,000	$999,500	$742,390	$1,194,100

The Vicksburg, Shreveport and Pacific Railroad crosses Bayou Maçon near Delhi, La. The New Orleans and Northwestern Railroad crosses Tensas River at Clayton, Concordia Parish, La.

T 8.

IMPROVEMENT OF YAZOO RIVER, MISSISSIPPI.

Yazoo River, about 173 miles long, is formed by the junction of Tallahatchie and Yalobusha rivers, in Leflore County, Miss., flows in a general southerly and then southwesterly direction, and enters Mississippi River 5 miles above Vicksburg.

An examination was directed by river and harbor act of June 10, 1872, with a view to removing wrecks of gunboats, steamers, and other obstructions placed in the river to bar navigation during the war, report upon which was made the following year. (Report Chief of Engineers, 1873, pp. 483, 484.) In 1874 a further examination was made, and estimates were submitted for thoroughly clearing the river of obstructions in a period of four years, at a cost of $120,000, small annual appropriations to be made thereafter for maintenance. (Reports Chief of Engineers, 1874, Part I, pp. 364–367, and 1875, Part I, p. 522.) The appropriations made were not sufficient to carry out this project, and the plan under which work has continued since 1875 contemplates the removal

of wrecks, snags, logs, leaning timber, etc., obstructing navigation, so far as the funds provided from time to time will permit. Floods, sliding and caving banks, etc., add new obstructions, and the work should be gone over yearly in the interest of safe navigation.

The appropriations have been as follows:

By act of—		By act of—	
March 3, 1873	$40,000	August 5, 1886	$15,000
March 3, 1875	12,000	August 11, 1888	32,000
August 14, 1876	15,000	September 19, 1890	25,000
June 18, 1878	25,000	July 13, 1892	20,000
March 3, 1879	15,000	August 17, 1894	20,000
June 14, 1880	12,000	June 3, 1896	20,000
March 3, 1881	6,000		
August 2, 1882	8,000	Total	275,000
July 5, 1884	10,000		

The first appropriation was applied in 1873–74 to the removal by contract of wrecks of nine vessels sunk during the war of the rebellion. After newspaper advertisement of fifty days, only two proposals were received, and the contract was awarded the lowest bidder for the sum of $35,450. Experience gained by this work showed that the improvement could be continued more economically by means of a snag boat owned and operated by the United States. In 1875 and 1877 the U. S. snag boat *O. G. Wagner* was used for the purpose, but since the completion of the snag boat *John R. Meigs*, in 1879, the principal work has been done by that vessel.

The amount expended to June 30, 1895, was $236,496.06. The results of the work done were marked. The large number of wrecks that blocked the channel at low stages and limited the period of navigation had been removed so as to present no obstruction, and the removal of snags, logs, leaning timber, etc., repeated from time to time, opened and maintained steamboat navigation from mouth to head the year round. The only obstacle of importance was the shifting bar at the entrance into Mississippi River, which prevented vessels entering or leaving the Yazoo at low stages. A project for diverting the mouth of the river so as to permit free passage through the same at all seasons of the year has been undertaken by the United States, and measures provided for completion of the work required, details of which are given in the succeeding report.

Snagging operations, etc., for general improvement of the river were not resumed during the fiscal year ending June 30, 1896. The U. S. snag boat *Columbia* passed over the river from mouth to head and back on a trip into Tallahatchie River in January 1896, but the stages were too high for effective work at the time. Owing to uncertainty of appropriations, it was deemed advisable to reserve the balance in hand, unless complaints should be made by the steamboats in the trade, in which event any special obstructions reported would have been removed. The snag boat *Meigs* and other plant pertaining to this work were laid up with the fleet at Vicksburg, Miss., kept in serviceable condition by repairs needed from time to time, and ready for immediate use if needed.

The recommendations and estimates contained in my reports of 1894 and 1895 respecting the streams of the Yazoo system are repeated, viz:

> Work in Yazoo and tributary streams could be carried on more economically if they were grouped together as a system and appropriations made under one head, with allotments for each stream. The plant could then be bought from the general appropriation and its use charged pro rata without being a heavy burden upon any one stream. A modern dredge, preferably self-propelling, would be of great use in parts of Yazoo, Tchula Lake, and Big Sunflower, but the largest appropriation of

late years for any one of the streams mentioned would not be sufficient for the purpose. So also with regard to pile drivers, quarter boats, or small hand-snagging outfits, the idea being to have a district plant, to be used on any of the streams of the system when needed. The estimates are made with this view, the work required not being of a kind that can be done advantageously or satisfactorily by contract. A great deal of work remains to be done in clearing the banks of leaning timber to prevent tree slides and snags, and to make the passage of the sharp bends safer, and this can be done most economically by shore parties housed and subsisted on quarter boats, leaving the heavy work to be done at the proper or convenient time by the snag boats. There are also many places where the channel is injured by dispersion, and where chutes should be closed or wing dams built. As Yazoo and tributaries are not subject to heavy drift, work of the kind need not be expensive, and probably sheet piling would answer very well.

DETAILED ESTIMATES.

General service plant:		
Dredge	$30,000	
Pile driver	4,000	
Quarter boats	2,500	
Skiffs, tools, rigging, etc	3,500	
		$40,000
Service of plant:		
Expenses of snag boats	24,000	
Expenses of dredges	9,000	
Expenses of shore parties	7,000	
		40,000
Care of plant:		
New boilers	4,000	
Hull repairs	3,000	
General and extraordinary repairs	1,500	
Fleet, wages, supplies, etc	1,500	
		10,000
Surveys: Local surveys, gauges, discharge measurements, etc		6,000
Administration:		
Office expenses, rent, supplies, etc	1,500	
Assistant engineers, draftsmen, transportation, and incidentals	2,500	
		4,000
Total		100,000

The appropriation of 1894 provided for "removing the bar at Yazoo City," and the provision was repeated in the act of 1896. There was no recommendation for such work from this office, and no complaints respecting the bar have been made. To determine whether dredging was advisable, and if so, where and how much, authority was granted by the Chief of Engineers to make a survey at the locality. A party under Assistant Engineer T. C. Thomas left Vicksburg on the U. S. S. *Columbia* June 21, reached Yazoo City the following day, completed field work June 26, and returned the next day to Vicksburg. Field work was as follows: Determination of latitude and meridian; a chain or traverse line for checking stadia work, distances being double-taped and angles determined by positive and negative repetitions with a 20″ transit; Y levels for determining slope and checking stadia elevations; soundings at intervals of 300 to 400 meters, except on bar in front of Yazoo City, where they were made 50 meters apart; stadia location of bank lines, sounding ranges, etc.; borings on bar, and discharge observations.

The notes are not plotted, and full report on the subject can not be made until this work is finished. In a preliminary report of June 30, 1896, Assistant Engineer Thomas makes the following statements, viz:

> The bar on the Yazoo City front evidently is formed by gravel brought down from the adjacent hills by Town Bayou. Similar bars were noticed at the mouths of all small streams entering the river at points where hill line approached. Scotts Bayou, emptying into river immediately above Yazoo City, is an apparent exception; but

this bayou runs for some distance through the bottom country before reaching the river.

The bar on the city front begins at mouth of Town Bayou, where it reaches practically across the river, and extends downstream several hundred meters. Borings on the bar made to depths of 3 and 3.2 meters show a gravel and sand deposit at bottom of borings. For a boring made to depth of 4.7 meters the fill dropped out of bottom of pipe for a distance of 0.3 meter, showing that pipe had reached a bed of quicksand. The material could be handled easily by a bucket and chain or hydraulic dredge.

The point opposite bar is protected by a fringe of willows. The bank has a fair slope and shows no evidence of recent caving, except directly opposite the mouth of Town Bayou. The channel lies against the point. The low-water depth is good, but the current is very strong at low stages and boats sometimes have to line past point. Steamboat men say they have no difficulty in getting to the lower landing at low water, and the soundings show good water at the upper landing, which is in the pool above the bar.

The sentiment of such citizens as expressed themselves on the subject was decidedly adverse to removal of the bar on the city front. The gravel bar immediately below the city sometimes gives trouble on account of the left bank sloughing off and contracting the low-water channel, which in such cases has sufficient depth, but is too narrow. This bar, like that on the city front, is caused by a small stream entering the river immediately from the hills.

Steamboat men complain that the railroad incline a short distance below the lower landing is a source of danger at high stages of the river. It seems to have been built to assert the riparian rights of the Illinois Central Railroad, and never has been completed.

The amounts expended during the year and balances available July 1, 1896, are as follows:

Allotments.	Expended during year.	Balances July 1, 1896.
General improvement, repairs, care of plant, etc	$3,453.23	$32,114.57
Survey at Yazoo City	490.84	409.16
Constructing pumping dredge boat (act of August 11, 1888)	----------	2,036.14
Total	3,944.07	34,559.87

Money statement.

July 1, 1895, balance unexpended	$18,503.94
Amount appropriated by act of June 3, 1896	20,000.00
	38,503.94
June 30, 1896, amount expended during fiscal year	3,944.07
July 1, 1896, balance unexpended	34,559.87
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	100,000.00

COMMERCIAL STATISTICS.

Above the mouth the river was navigable the entire year. The conditions at the mouth during the year, as near as could be determined, were as follows: Light-draft boats had trouble in getting over the bar July 4 to 9, August 19 to 25, and November 14 to December 2, 1895. During the following periods the mouth was closed to navigation: August 25 to September 10 and September 28 to November 13, 1895, or summarized as follows: Navigation difficult, thirty-two days; closed sixty-four days. The trouble usually becomes manifest at about a 10-foot stage on the Kleinston gauge.

List of steamboats engaged in navigating Yazoo River during the fiscal year.

Name.	Class.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Between—	Round trips.	Passengers.
						Light.	Loaded.			
			Feet.	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*			
Novelty	Stern-wheel.	63.4	76.4	16.4	3	1 3	3 6	Vicksburg and Big Sunflower River.	26	115
Atlanta	...do ..	85.03	93	16.4	3.7	2 0	3 6	Vicksburg and Big Sunflower River.	2	10
Ed. Durant, jr.*	...do ..	153.49	113.6	29.6	4.6	1 8	3 6	Vicksburg and Satartia.	1	.....
								Greenwood and Tallahatchie River.	3	.....
								New Orleans and Yazoo River.	1	.....
E. A. Pharr	...do ..	63.61	90	29.9	4.2	2 4	4 0	Greenwood and Sharkey.	14	8
								Greenwood and Sheppardtown.		
Ferd R.†	...do ..	45.5	93	16	3	1 1	3 0	Greenwood and Sharkey.	50	20
								Greenwood and Sheppardtown.		
Lake Palmyra	...do ..	141	123.5	26	4.8	2 6	5 10	Vicksburg and Big Sunflower River.	14	126
White Oak†	Tug ..	31.32	69	13	6.4	5 6	8 6	New Orleans and Big Sunflower River.	1	.....
J. B. O'Brien†	...do ..	44.49	70.8	15.2	7	7 10	9 0	Yazoo City and Natchez.	2	.....
Laurens	.....	.....	.....	.....	.....	.....	.....	New Orleans and Big Sunflower River.	1	.....
L. L. B	Stern-wheel.	6.54	36.6	16.7	2.3	.....	.....	Brashear, La., and Yazoo and Tallahatchie Rivers.	1	.....
Mary Joyce†	...do ..	34.64	65	14	2.4	1 1	2 0	Vicksburg and Big Sunflower River.	4	.....
John F. Allen	...do ..	133.9	130.2	24	4.2	1 8	4 0	Vicksburg and Greenwood.	30	175
								Vicksburg and Tallahatchie River.	60	221
								Vicksburg and Tchula.	10	36
Birdie Bailey†	...do ..	109.7	111	22	3.5	1 10	4 0	Yazoo City and Belzona.	150	1,253
								Yazoo City and Tchula.	3	14
Blanks Cornwall	...do ..	232.4	140	29	4.6	2 2½	5 2	Vicksburg and Greenwood.	4	37
								Vicksburg and Tallahatchie River.	4	63
								Vicksburg and Tchula.	4	72
Hibernia	...do ..	157.06	135	25	4	2 6	4 0	Vicksburg and Belzona.	40	506
								Vicksburg and Big Sunflower River.	15	247
Yazonia†	...do ..	62.84	95	19.8	3.5	1 3	3 6	Vicksburg and Belzona.	16	76
								Vicksburg and Big Sunflower River.	19	176
								Vicksburg and Tchula.	4	7
Maggie†	...do ..	50.73	85	19	3.5	1 3	3 0	Yazoo City and Big Sunflower River.	40	428
Fifteen†	...do ..	75	103	18	3.5	1 8	3 0	Yazoo City and Big Sunflower River.	12	113
								Greenwood and Sharkey.	67	198
Joe Seay*	Tug ..	27.74	75	16	7	6 0	7 6	Vicksburg and points on Yazoo River 25 miles above mouth.	25	.....
								Vicksburg and Big Sunflower River.	2	.....
								Vicksburg and Redwood.	3	.....
Little Joe†	...do ..	18.07	44.5	10	4	5 6	5 9	Vicksburg and Greenwood.	1	.....
								Vicksburg and Redwood.	3	.....

* Towboats.

† With one or more barges.

List of steamboats engaged in navigating Yazoo River, etc.—Continued.

Name.	Class.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Between—	Round trips.	Passengers.
						Light.	Loaded.			
			Feet.	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*			
Thos. A. Hendricks	Stern-wheel.	81.86	108	22.5	4.2	4 2	5 0	Vicksburg and Greenwood.	3	.....
John M. Abbott	.....	.....	.....	.....	.....	.....	.....	No report.	.....	.....
Mima	.....	.....	.....	.....	.....	.....	.....	do	.....	.....

Summary of commerce reported.

Articles.	1895–96.	1894–95.	1893–94.	1892–93.	1891–92.	1890–91.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Cotton	14,403	17,037	15,815	11,094	15,653	13,750
Cotton seed	17,150	19,432	17,355	12,795	16,570	12,500
Hides and skins	12	11	10	26	19	10
Live stock	52	47	60	79	124	60
Lumber	1,613	10,080	3,200	3,122	3,318	3,600
Staves	23,740	10,623	14,447	12,488	6,864	1,350
Provisions	13,520	13,325	12,020	8,547	10,502	9,020
Grain	7,018	13,760	14,280	6,107	12,531	11,080
Saw logs	31,200	11,000	22,400	11,800	15,000	2,140
Miscellaneous	18,863	17,725	12,200	8,507	12,624	10,540
Total freights for Yazoo proper	127,571	113,040	111,787	74,565	93,205	64,050
Total freights from tributaries	85,374	107,551	136,394	124,887	116,021	97,588
Total freights Yazoo and tributaries	212,945	220,591	248,181	199,452	209,226	161,638
Estimated value	$3,619,000	$4,806,000	$8,314,000	$4,329,000	$7,351,500	$6,315,275

Of the above freights Tchula Lake contributed 2,934 tons, valued at $200,000.

When the mouth of the river is closed to navigation, the sources of supplies for Yazoo and tributaries are Yazoo City and Greenwood.

The Georgia Pacific Division of the Southern Railway crosses Yazoo River at Fort Loring, 5 miles below Greenwood, and the Yazoo and Mississippi Valley Railroad crosses about 15 miles above the mouth. The latter has a branch from Clarksdale to Philipp, on the Tallahatchie, connecting with a branch of the Georgia Pacific to Greenwood. The Yazoo branch of the Illinois Central Railroad, from Parsons, on the Yallabusha, to Jackson, Miss., runs parallel to the river, touching at Greenwood, Sidon, Tchula, and Yazoo City, and has a tap line from Tchula to the main line at Durant.

T 9.

IMPROVEMENT OF MOUTH OF YAZOO RIVER AND HARBOR AT VICKSBURG, MISSISSIPPI.

The shifting bar at mouth of Yazoo River is the most serious obstruction to navigation of that stream and its tributaries, and boats that could make trips into the chief streams of the Yazoo Valley system (about 800 miles of navigable waterway) without hindrance are prevented at low stages from entering or leaving without lightering across the bar, and frequently navigation is closed altogether.

The river and harbor act approved September 19, 1890, provided the sum of $5,000 to "be used in making a survey of the Yazoo River from the bridge of the Louisville, New Orleans and Texas Railway to its mouth, for the purpose of determining in what manner the mouth of the river can be so improved as to freely permit the passage through the same, at all seasons of the year, of vessels engaged in the navigation of the river; and said survey shall also include an investigation into the feasibility and advantages of making a new mouth or outlet for

said river, by way of Chickasaw Bayou, or otherwise, together with an estimate of the cost of the same."

The survey was made under my direction, and the report and maps were submitted February 4, 1892. The report was printed in House Ex. Doc. No. 125, Fifty-second Congress, first session, and reprinted in Report of the Chief of Engineers for 1892, Part II, pages 1627–1642. The project contemplated the formation of a new outlet from former mouth of Yazoo on Old River, through deep water in Old River, across the lowlands between Long and Barnett lakes to Lake Centennial, around the head of De Soto Island, along the front of Vicksburg, and entering the Mississippi River on the channel side at Kleinston. A basis of 2 meters below zero of the Kleinston gauge was given, so that the depth always should be sufficient for boats that can navigate Yazoo River at low water; the cut or canal from Old River to Lake Centennial was to be not less than 30 meters wide, with side slopes not steeper than 1 upon 2, unless it should be found better to cut full width for equal areas without regard to side slopes; and the greater part of the material excavated in digging the canal was to be put in Lake Centennial, below head of De Soto Island, to make a solid filling for the new right bank across the west arm of the lake, which was to be revetted if found necessary. The West Pass of Lake Centennial was to be closed and filled to ordinary high water. Dredging was to be carried through Lake Centennial to Kleinston. Along the land cut small levees were to be built on each side at the limits of the right of way, and banks were to be built at the edges of the berme for footings for deposit of about one-third of the material excavated, to raise the lowlands to grade and prevent dissipation of Yazoo into the swamp below and thence across to the lake and Mississippi River. A levee above highest floods should be built along left bank of Yazoo River and down wrong end of Old River to join the levee and embankment on left bank of land cut. As Yazoo River fills in the lower section and scours as the rivers fall, it would continue to fill but cease to scour after the new mouth is opened, so that it seems probable that a dam will not be needed below the turn at head of Old River, and with this view the work of building such a dam was put last, with the expectation of omitting it altogether. The distance from old mouth of Yazoo River at head of Old River to Kleinston is 14.2 miles; by the new route it will be 9.3 miles. The original estimates of cost of the work, on a basis of completion in three years, amounted to $1,500,000, but were revised in my report for 1893 and the amount reduced to $1,200,000.

Appropriations have been made as follows:

Date of act.	Purport.	Amount.
July 13, 1892	Improving mouth of the Yazoo River, Mississippi, in accordance with plan of Capt. J. H. Willard, dated February 4, 1892, contained in House Ex. Doc. No. 125, Fifty-second Congress, first session, including borings and gauges.	$75,000
	Should the Secretary of War be unable to obtain such right of way as may be necessary in the prosecution of this work, upon reasonable terms, by agreement, purchase, or voluntary conveyance, he is hereby authorized to apply at any term of the circuit or district court of the United States for the western division of the southern district of Mississippi, and in the name of the United States institute and carry on proceedings to condemn such lands as may be necessary for right of way as aforesaid, and in such proceedings said court shall be governed by the laws of the State of Mississippi, so far as the same may be applicable to the subject of condemning private property for public use.	
Aug. 17, 1894	Improving mouth of the Yazoo River, Mississippi, continuing improvement, to be expended in accordance with plan of Capt. J. H. Willard, as set out in House Ex. Doc. No. 125, Fifty-second Congress, first session.....	225,000
Do.....	Improving harbor at Vicksburg, Miss., not including work at Delta Point, La., continuing improvement under the direction of the Secretary of War.	40,000
	Total	340,000

The river and harbor act of June 3, 1896, provided for completion of the work by the following item, viz:

Improving mouth of Yazoo River and harbor of Vicksburg, Miss.: For the purpose of completing the project of improvement as heretofore adopted and entered upon, in addition to expending the balance on hand, contracts may be entered into by the Secretary of War for such materials and work as may be necessary to complete the same, or said materials may be purchased and work may be done otherwise than by contract, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate $860,000, exclusive of the amount heretofore appropriated.

Payments for obligations that may be incurred under this act are limited by section 5, as follows:

SEC. 5. That under the authority to make contracts for materials and work, under the provisions of this act, in addition to the sums appropriated herein, the Secretary of War shall not obligate the Government to pay, in any one fiscal year, beginning July 1, 1897, more than $400,000 upon the said contracts for any one of the works herein placed under the contract system, except as herein otherwise specifically authorized to do: *Provided*, Any part of the annual allotment herein provided for, not earned and paid for material furnished or work done in one fiscal year, may be paid for material furnished and work done under the contracts in any subsequent fiscal year: *Provided further*, That nothing herein contained shall be so construed as to prevent the Secretary of War from making contracts for the whole or any part of the works placed under the contract system in such manner as may be deemed best, payments, however, to be made as stated in this section.

As the plan submitted in House Ex. Doc. No. 125, Fifty-second Congress, first session, contemplated dredging Vicksburg Harbor to a depth of two meters below zero of the Kleinston gauge, in diverting the mouth of the Yazoo River by way of the new outlet, both items of appropriation by act of August 17, 1894, were treated in a single project, in accordance with section 2 of river and harbor act of 1890. Work in Vicksburg Harbor had been carried on under the Mississippi River Commission for some years, but was transferred to this district in 1892, as a part of the general project for diverting the mouth of the Yazoo, when work under the Commission ceased. On June 30, 1895, the amount expended for work under previous projects at Vicksburg and at Delta Point, opposite the city, was $684,304,65.

The amount expended under the present project to June 30, 1895, was $43,717.77. At that time the following work had been done, viz: The maps were finished on a scale of 1:5,000, and a final line selected for the excavation from Old River to Lake Centennial, along which borings, extending below bottom grade of proposed cut, had been made at frequent intervals and the character of the material determined. The line of precise levels of the original survey from Kleinston to the railroad bridge near Redwood was extended upstream to Yazoo City, thence along the railroad to Greenwood, near the head of Yazoo River, and thence westward along the railroad to the permanent benches of the Coast and Geodetic Survey and Mississippi River Commission at Greenville, Miss., and discharge measurements were taken and computed. Property lines between Old River and Lake Centennial were traced on the ground and the limits of the right of way to be acquired ascertained and marked. Abstracts of title were prepared from the county records, and, the Attorney-General having given opinion as to validity of titles, definite offers to sell the lands required were obtained from the owners and the purchases authorized by the Secretary of War. A base for future levels along the whole route from Old River to Kleinston was measured with steel tape, and reference points, marked with vitrified pipes filled with cement, were set every 50 meters. Between Old River and Lake Centennial the pipes were set on both sides of the route 100 meters from the center line. The entire

line was cleared from Old River to Kleinston, and June 30, 1895, the work of grubbing and blasting for removal of stumps was about half done. In clearing the lands a large amount of very heavy timber—oak, black gum, and pecan—was felled, too heavy to be hauled by teams, and it was decided to leave it to be towed out at high water by snag boats, marking buoys having been attached to the logs by wire. A considerable amount of timber was cut into suitable lengths and cribbed, to be towed into Lake Centennial and weighted down as a foundation for the dam across the west arm of the lake. The work of clearing and grubbing was exceeding heavy, and, as it was of a kind difficult to let by contract, was done by hired labor at a cost considerably less than estimated.

During the fiscal year ending June 30, 1896, work continued as follows:

After delays from various causes all the lands required for the right of way for the cut from Old River to Lake Centennial were acquired in December, 1895, and jurisdiction over the same for the purpose of improving the mouth of Yazoo River was ceded to the United States by the governor of the State of Mississippi, under an act of the legislature approved February 2, 1894. The right of way is 1,000 meters wide and located to give the least amount of excavation and an easy curve for change of direction from Old River to Lake Centennial. The total quantity of land purchased was 1,155.54 acres, at a cost of $34,254.68, or an average price of $29.64 per acre.

The ditch for draining Barnett Lake into Willow Bayou, requiring excavation of 5,165 cubic meters of earth, was completed in August, and lowered the water surface sufficiently to permit the removal of stumps. Grubbing and blasting stumps by hired labor was completed in January, 1896, after which a small force was employed in removing the heavy growth of vines and brush from logs along the right of way, attaching marking buoys with wire, piling and burning roots, stumps, etc. A boom was built across the mouth of the proposed canal at Lake Centennial, and the cribs of timber and floating logs and stumps were moved out to it, as far as practicable.

It having been considered advisable to do a certain part of the land cut where the ground was highest by scrapers, so that dredges may operate over the elevated portions at high stages, entering as the water rises and withdrawing to the lower lands as it falls, and also to permit the logs to be towed off the right of way the first high stage, the work was recommended by me October 3, 1895, approved by the Secretary of War October 10, and the sum of $20,000 allotted for the purpose. The work was advertised October 15, and proposals opened October 31, 1895, as per abstract attached to this report. The award was made to C. H. Dameron & Bro., the lowest bidders, and contract entered into November 7, and approved by the Chief of Engineers November 23, 1895, requiring commencement of work on or before November 21, 1895, and its completion by January 31, 1896. On account of unavoidable delays, the limit of the contract was extended to March 1, 1896, under authority of the Chief of Engineers dated January 27, 1896. The work consisted of the removal of a portion of the earth from the high bank on the Lake Centennial end of cut, between stations 134 and 138, and on the Old River end between stations 192 and 205, for a width ranging from 140 to 180 meters, and a depth from 0 to about 2 meters. The dirt excavated was hauled to and deposited in continuous banks on both sides, about 100 meters from the corresponding edges of the cut. The tops of the banks were put at a uniform grade and the

sides sloped as usual for levee work. Work under the contract was commenced November 20, 1895, and completed February 21, 1896. Careful final measurement showed the entire amount of work done under the contract to have been 89,089 cubic meters, which, at 20.8 cents per cubic meter, cost $18,530.51.

The highest stage on the Vicksburg gauge during the year was 39 feet, April 21, 1896, and April 20–24, the U. S. snag boat *Columbia*, P. R. Starr, master, was employed in towing logs from the high ground above station 134, Vicksburg gauge ranging from 38.9 to 37.7 feet during the period. The rapid fall caused suspension of this work April 25, the boat having been used that day in anchoring the rafted timber at site of dam in Lake Centennial. Since April a small force has been employed in piling and burning the logs on the right of way.

Two hundred and sixty-two reference signs made of sheet iron, with section number painted thereon, were riveted to gas pipes and erected above high water at the points marked along the land cut during the year.

Attention is invited to the report of Assistant Engineer H. M. Marshall, hereto appended, giving details of the year's work.

Money statement.

July 1, 1895, balance unexpended	$296,282.23
June 30, 1896, amount expended during fiscal year	88,717.18
July 1, 1896, balance unexpended	207,565.05
July 1, 1896, outstanding liabilities	24.60
July 1, 1896, balance available	207,540.45
Amount (estimated) required for completion of existing project	860,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	400,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

Abstract of proposals for about 100,000 cubic meters of excavation and embankment between Old River and Lake Centennial, near Vicksburg, Miss., received in response to advertisement dated October 15, 1895, and opened at Vicksburg, Miss., October 31, 1895, by Maj. J. H. Willard, Corps of Engineers.

No.	Name and address of bidder.	Price per cubic meter.
		Cents.
1	McLaughlin Bros., Memphis, Tenn	22
2	A. P. Martin, Waterproof, La	21.5
3	C. H. Dameron & Bro., Huntsville, Mo.*	20.8
4	Michael O. Gorman, Vicksburg, Miss	24.5

* Bid accepted.

REPORT OF MR. H. M. MARSHALL, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., June 15, 1896.

MAJOR: I have the honor to submit the following report on improving Yazoo River at the mouth for the fiscal year ending June 30, 1896:

Work of grubbing and blasting stumps, which was about half finished at the beginning of the year, was completed. The work was classified and systematized, so that the labor of a squad of men was as simple as possible, and of the same character every day; that is to say, first a squad consisting of about 18 men under a

foreman worked over a section, digging around the stumps with mattock and shovel, usually two men to a stump. They cut off and dug out all lateral roots, following them out until the root became less than 5 centimeters in diameter. If a stump was not too large or too deep in the ground to permit all the earth to be removed from around it without handling twice it was dug out. If the stump could then be lifted out of the hole by four men it was taken out, otherwise it was left to be shattered by another squad. If the digging would have required handling the earth twice to get the stump out it was left as soon as the first handling was completed, and such stumps were subsequently blasted. The foreman made daily report of work accomplished, on what section performed, the number of men employed, and the time each labored. The work accomplished show number of stumps from 0.1 meter to 0.3 meter in diameter, 0.3 to 0.6 meter, 0.6 to 0.9 meter, etc., measured at the ground surface, which were "dug and taken out," "dug and left," and "dug around ready for blasting." All growth less than 0.1 meter was removed by mattock and reported as "mattocking on section, thick or thin," as the case might be. The itemized cost of the total or partial removal was worked out by stating the daily work and cost in the form of an equation, then forming groups having dissimilar coefficients, and from these obtaining a mean set of equations. Table 1 gives the average cost of each size stump. There were four squads generally engaged in the work just described.

Next a squad of 12 men and a foreman did the blasting. Nine men went over the section boring holes into the ground under the stumps left to be blasted and into the stumps to be shattered, the number of holes varying with the size of the stump from two to eighteen, and the depth from 1 to 2 meters in the blasted stumps, and from one to four in number and 0.3 to 0.6 meter in depth in the shattered ones. Ship augers 5 centimeters in diameter, having shanks 1.3 meters long, were used for boring into the earth, and rafting augers of like diameter into the wood. To deepen the holes under large stumps, augers having shanks 2 meters long were used in the holes first bored with the shorter ones; that is, five men bored all holes into the earth, two men deepened those under large stumps, and two other men bored holes into the stumps. One man charged the holes with Judson powder, using a tin scoop to pour it into the holes. Two men inserted the dynamite, usually half of a half-pound stick with a platinum fuse buried in the end or side, and tamped the hole with earth, leaving the fuse wires extending above ground. Where ground water filled the holes it was found better to use dynamite alone. The foreman connected all the wires around one large or several small stumps in a group so as to be ready for blasting. Just before dinner and again before quitting time the foreman in a few minutes fired all the blasts by means of a magneto-electric battery, the three men shifting the lead wires from one group to another as rapidly as the blasts were made. Daily report gave number of holes bored, number and size of stumps blasted and shattered, number of fuses, amount of powder and dynamite exploded, and time of labor.

A gang of 18 men under a foreman then dug out with mattock and shovel all roots left after blasting. No attempt was made to remove or destroy the roots and stumps, as it was anticipated they would float off during high water. This was in part fulfilled, but the river did not reach a sufficient height nor remain up long enough to permit its accomplishment on the higher ground.

During the summer season the laborers were subject to malarial attacks, probably brought on by drinking water from shallow wells which were driven about 10 meters deep. It was very easy and convenient to pull up one of these wells and redrive it as the work progressed, so as to have water close at hand. The water was clear and cold, with only a slight astringent taste, but if left exposed in a vessel for a few hours a scum formed on top. A deeper well, 56.5 meters was driven, having the outside pipe 6 centimeters in diameter and a pipe inside 3 centimeters in diameter. The outer pipe was entirely open at the bottom, and after driving filled up with sand for a considerable distance. The inner pipe had a sieve-strainer point 7.5 meters in length on the bottom to prevent the inflow of sand, and water was brought up through this inner pipe by an ordinary plunger hand pump. While driving the strainer was left off and water was forced down the inner pipe and flowed out of the top of the outer one. A hand force pump was first tried for this purpose, but proved too weak, and a small steam pump was substituted. The inner pipe had a heavy clamp bolted near the top to serve as a hammer head, and the pipe being supplied with water through a section of hose it could be raised and dropped freely so as to drive the outer pipe at the same time that the jet at the bottom of the inner pipe washed away the material. The material consisted of alternate layers of clay and sand. The clay beds varied from 1 to 3 meters thickness and the sand became coarse, even to the size of small gravel, and the beds thicker as the depth increased. The bottom of the well is 24.8 meters below Cairo datum. The water rises to 26.2 meters Cairo datum, or within 5.5 meters of the surface. It is clear, sparkling, and moderately cold, with a slight taste, probably due to iron. Since using it the men have been nearly exempt from malarial diseases.

To build a levee on each side of the cut through the main bank between Old River and Lake Centennial to confine the flow through the cut, to prevent cross-currents, also to uncover any buried stumps within the cut, to make the dredging less in amount and easier in character, and to provide a dumping ground for the waste material, the surface was removed by scrapers from the full width of the proposed channel through the cleared land adjacent to the ends. The earth was deposited in embankment on both sides parallel to the cut, and 100 meters from the edge. The excavation extended from station number 134 to 138 at the lower end, and from 192 to 205 at the upper. The depth of cut varied from 0.3 to 1.3 meters, and the quantity of earth removed was 89,089 cubic meters. The work was advertised October 15, 1895, bids were opened October 31, and the award made to C. H. Dameron & Bro., the lowest bidders, at the price of 20.8 cents per cubic meter. Work began November 20, and, under the contract, should have been finished January 31, 1896, but on account of bad weather the time was extended to March 1. Work was completed February 21. All measurements were made and estimates given in the metric system without disagreement of any sort with the contractors. This probably is the first instance of the use of the metric system in a public contract of this character.

As soon as the river rose sufficiently in the spring, men were put to work in small boats rafting the logs and stumps. Logs were formed into a boom inclosing a number of other logs and stumps, and towed out into Lake Centennial to the site of the dam to be built across its western arm. When the stage of water was insufficient to tow into Lake Centennial a considerable raft was formed in Barnett Lake. For a week in the latter end of April the water was at a sufficient height to permit employing the snag boat *Columbia*, both in towing the rafts and in pulling up the sunken logs to which wire cables and buoys had been attached. She did excellent work under the supervision of P. R. Starr, master, and with a slightly higher stage of longer duration would have completed the work at great saving of cost. The further removal has been in part accomplished, and will be completed shortly by piling and burning. This, while more expensive, will permit excavation of the top surface from the remainder of the main cut.

After the water had fallen in May an attempt was made to sink the rafted timber by dredging along the edge and depositing the material by means of a belt conveyor on top of the raft. An elevator bucket dredge, built by the Bucyrus Steam Shovel and Dredge Company, did the work, but because of the looseness of raft not much was accomplished in the sinking. When covered by a willow mattress the result probably will be more satisfactory.

Reference numbers were erected 1 meter behind the base-line monuments, as described in the last annual report.

Very respectfully, your obedient servant,

H. M. MARSHALL,
Assistant Engineer.

Maj. J H. WILLARD,
Corps of Engineers.

Average cost of grubbing and blasting stumps.

	Diameter at ground surface, meters.					
	0.1 to 0.3.	0.3 to 0.6.	0.6 to 0.9.	0.9 to 1.2.	1.2 to 1.5.	1.5 to 1.8.
Grubbed with pick and shovel	$0.13	$0.45	$0.64	$0.70	(*)	(*)
Grubbed ready to blast	.....	(*)	.57	.95	$1.30	$1.62
Blasted	.....	(*)	1.01	1.71	2.22	4.28
Shattered	.....	.....	.41	.41	.41	.41

(* Stumps too few in number to get reliable results.

COMMERCIAL STATISTICS.

During the fiscal year the canal or harbor from Kleinston to the Vicksburg landing, at foot of Crawford street, practically was closed to navigation from July 1 to December 29, 1895, and from January 20 to February 9, 1896. The first Anchor Line steamer came in April 4. Soundings taken the latter part of June, 1896, show that the present bed of the canal corresponds to an elevation of 12.7 feet on the Kleinston gauge. The Anchor Line and other Mississippi River packets can come to the city front at a stage of about 23 feet on the Kleinston gauge. The local ferry and the Yazoo and Big Sunflower packets can come in on a stage of about 17 feet.

List of steamboats arriving at and departing from Vicksburg in the fiscal year 1896.

Name.	Class.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Arrivals.	Departures.	Passengers.
						Light.	Loaded.			
			Feet.	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*			
City of Hickman	Side-wheel.	1,555.17	285	44.5	9.5	3 3	9 8	30	30	9,160
City of Monroe	...do ..	1,038.25	275	45	8	3 3	.....	26	26	
City of New Orleans	...do ..	1,586.28	290	48	8.5	3 6	9 6	16	16	
City of St. Louis	...do ..	1,614.02	300	49	8.8	3 6	9 0	24	24	
Arkansas City	...do ..	1,236.99	273.7	44.7	7.8	3 6	8 6	18	18	
Benton	Stern-wheel.	394.08	197	33	5	.....	.....	4	4	.....
City of Sheffield	...do ..	329.74	183	35	5.5	.....	.....	2	2	.....
Mary Morton	...do ..	450.64	210	32.5	6	.....	.....	2	2	.....
Joseph Henry	...do ..	340	180	32	5.8	.....	.....	2	2	.....
J. N. McComb	...do ..	.....	176.9	62	7	.....	.....	6	6	.....
Mississippi	...do ..	390.14	174	32	6	.....	.....	4	4	.....
Buckeye State	...do ..	669.92	252.3	39.2	6.8	3 0	9 0	16	16	289
State of Kansas	...do ..	1,130.34	252	52.6	6	2 6	7 0	16	16	312
New South	...do ..	846.55	257	42.6	7	4 0	10 0	16	16	507
John K. Speed	...do ..	1,090.27	261	42	8.6	3 6	10 0	16	16	413
Joe Peters	...do ..	426.30	177.2	34.4	4.8	1 10	5 0	17	17	935
Natchez	...do ..	584.99	225	40	8	.....	.....	47	47	.....
T. P. Leathers	...do ..	509.47	220	40	6.5	.....	.....	29	29	.....
Pargoud	...do ..	594.50	242	43	7.6	.....	.....	10	10	.....
Danube	...do ..	232.32	175	33.8	5.1	2 0	5 6	1	1	.....
Henry Marx *	...do ..	199.57	138	30	4.5	.....	.....	2	2	.....
St. Joseph	...do ..	277.13	170	32	4.9	2 4	6 0	128	128	18,000
Charles D. Shaw	...do ..	186.03	132	25	4.3	1 8	4 0	37	37	.....
Annie Laurie	...do ..	199.81	138	27	4.8	3 0	6 6	156	156	15,000
Ruth	...do ..	217.90	160	31.5	5	3 0	6 6	46	46	1,700
Blanks Cornwall	...do ..	232.41	140	29	4.6	2 2	5 2	8	8	100
John F. Allen	...do ..	133.90	130.2	24	4.2	1 8	4 0	23	23	221
Hibernia	...do ..	157.06	135	25	4	2 6	4 0	24	24	360
Fifteen†	...do ..	75	103	18	3.5	1 8	3 0	2	2	20
Yazonia	...do ..	62.84	95	19.8	3.5	1 6	3 6	5	5	76
Lake Palmyra	...do ..	141	123.5	26	4.8	2 6	5 10	27	27	126
Novelty	...do ..	63.40	76.4	16.4	3	1 3	3 6	27	27	115
Mimat†	...do ..	62.72	66	17	3.2	1 2	2 6	2	2	20
Des Arc	...do ..	40.88	95	18	3	1 2	3 0	1	1	.....
Uncle Billy	...do ..	79.81	88	17.7	3.9	1 4	3 0	1	1	.....
Atlanta	...do ..	85.03	93	16.4	3.7	2 0	3 6	3	3	10
Mattie M	...do ..	73.45	95	24	2.8	1 8	3 6	1,460	1,460	18,250
Will Davis*	...do ..	75	100.8	23.6	3.6	.....	.....	1	1	.....
Ed. Durant, jr.*	...do ..	153.49	113.6	29.6	4.6	1 8	3 6	2	2	.....
Mary Joyce	...do ..	34.64	65	14	2.4	1 1	2 0	8	8	.....
White Oak†	Tug ..	31.32	69	13	6.4	5 6	8 6	1	1	.....
Joe Seay†	...do ..	27.74	75	16	6	7 0	8 0	40	40	.....
J. B. O'Brien†	...do ..	44.49	70.8	15.2	7	7 0	9 0	2	2	.....
Joe†	...do ..	18.07	44.5	10	4	5 6	5 9	28	28	.....
Thos. A. Hendricks*	Stern-wheel.	81.86	108	22.5	4.2	4 2	5 0	4	4	.....
City of Savannah	...do ..	335.55	186	31	5	2 4	6 6	24	24	1,790
Crescent*	...do ..	239.96	144	28	5	.....	.....	1	1	.....
Henry Lowrey*	...do ..	646.79	209.6	35.2	5.3	.....	.....	3	3	.....
H. M. Townsend*	...do ..	87.70	116.7	18	3.1	.....	.....	1	1	.....
Alarm*	...do ..	189.09	142	26	4.3	.....	.....	1	1	.....
Wash Honshell*	...do ..	134.99	157	28.6	4	.....	.....	1	1	.....

* Towboats. † With one or more barges.

Summary of commerce reported for fiscal year 1896.

Articles.	Yazoo River and tributaries.	From Mississippi River.	Total.
	Tons.	*Tons.*	*Tons.*
Cotton	20,193	4,911	25,104
Cotton seed	29,161	13,498	42,659
Coal	.....	15,000	15,000
Lumber	4,487	2,036	6,523
Saw logs	37,000	30,000	67,000
Staves	63,762	180	63,942
Live stock	191	240	431
Hides and skins	33	133	166
Grain	7,443	21,325	28,768
Provisions	20,450	15,495	35,945
Miscellaneous	30,225	14,400	44,625
Total	212,945	117,218	330,163
Estimated value	$3,619,000	$4,088,000	$7,707,000

The steamers *Pargoud*, *Natchez*, and *T. P. Leathers*, of the New Orleans, Vicksburg and Bends Packet Company, and the *Alarm*, *Crescent*, and *Henry Marx*, of the Interstate Transportation Company, though furnished the necessary forms and copy of the law of February 21, 1891, failed to render reports of their commerce to and from the port of Vicksburg. In addition to the official requests the board of trade of Vicksburg appealed, both by mail and telegraph, to the first-named line, but could get no response. As these boats are large carriers to and from Vicksburg the commerce reported from Mississippi River is incomplete, and the total tonnage and value greatly reduced.

The Vicksburg Cotton Exchange reports the receipts of cotton from all sources for year ending June 19, 1896, i. e., handled at Vicksburg, as 65,903 bales.

Vicksburg cotton compress reports total receipts of cotton by river, 19,000 bales, and the Vicksburg Cotton-Seed Oil Mills report cotton seed received by river as 542,900 sacks.

Receipts and shipments reported by railroads.

Articles.	Alabama and Vicksburg and Vicksburg, Shreveport and Pacific railroads.		Yazoo and Mississippi Valley Railroad.	
	Received.	Shipped.	Received.	Shipped.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Cotton	27,155	10,255	4,770	26,015
Cotton seed	3,171	.....	12,414	.....
Coal	.....	26,007	4,520	.....
Lumber	6,428	3,586	2,120	5,450
Staves	.....	755	1,470	.....
Live stock	418	1,163	.....	520
Grain	3,130	6,225	4,732	2,392
Provisions	10,771	6,382	8,455	6,205
Miscellaneous	14,413	77,686	35,341	28,835
Total	65,486	132,059	73,822	69,417

	Tons.
Total receipts of railroads	139,308
Total shipments of railroads	201,476

T 10.

IMPROVEMENT OF TALLAHATCHIE RIVER, MISSISSIPPI.

Tallahatchie River has its source in Tippah County, northern Mississippi, near the Tennessee State line; flows in a general southwesterly direction until joined by Coldwater River, in Quitman County, and then, as the main stream, in a southerly direction through Quitman, Tallahatchie, and Leflore counties, uniting with the Yalobusha a few miles above Greenwood in forming Yazoo River. By most geographers the stream below the mouth of Coldwater is called Yazoo River.

An examination was made in 1878, under river and harbor act of that year. Low-water navigation was found to be much obstructed by snags, sunken logs, leaning timber, etc., and by the wreck of the ocean steamship *Star of the West*, sunk during the war of the rebellion, 8 miles above the mouth. The project contemplated removing these obstructions to give ease and safety to navigation from head of Yazoo River to mouth of Coldwater River, about 100 miles above, and it was proposed to do the work then required in two successive seasons at a cost of $40,000. (Report Chief of Engineers, 1879, p. 985.)

The following appropriations have been made:

By act of—		By act of—	
March 3, 1879	$6,000	September 19, 1890	$5,000
June 14, 1880	9,000	July 13, 1892	5,000
March 3, 1881	3,000	August 17, 1894	4,000
August 2, 1882	3,000	June 3, 1896	4,000
July 5, 1884	3,000		
August 5, 1886	3,500	Total	50,500
August 11, 1888	5,000		

By the terms of the acts $5,000 of the appropriation of 1880, $2,000 of the appropriation of 1881, and all of the appropriation of 1882, a total sum of $10,000, was required to be expended above mouth of Coldwater to Batesville, in the part known as Little Tallahatchie.

The total amount expended to June 30, 1895, was $42,856.10, of which the laws required $10,000 to be applied to a part of the river not included in the original project. Work commenced in the fall of 1879 and continued at intervals when funds were available. Details of operations are given in my last report. While the original project proposed to complete the work in two years, at a cost of $40,000, small and intermittent appropriations prevented carrying out the plan; the total amount provided for seventeen years' work having been but $36,500, permitting an average annual expenditure of $2,147.

Before the improvement was undertaken the river was navigable to Sharkey Landing, about 65 miles above the mouth, for about six months of the year, but the passage of steamboats was difficult and dangerous on account of snags and leaning timber. Above Sharkey to mouth of Coldwater it was almost impossible for boats to navigate at any stage, the leaning timber along both banks nearly meeting across the stream. The work done enabled steamboats to run to Sharkey the year round, and above that place to Coldwater River at high stages.

The work in Little Tallahatchie River, above mouth of Coldwater to Batesville, 1880–1882, resulted in no benefit, as there has been no trade in that part of the stream since the war.

New obstructions are brought into the river every year by drift and sliding and caving banks, and the shifting and scouring of the channel exposes snags and logs embedded in the bottom from time to time or lodges them upon bars. An appropriation sufficient to permit the systematic clearing of the banks, in addition to snagging operations, could be expended profitably in one season of low water, would result in lasting benefit to navigation, and but small amounts would be needed for maintenance.

During the fiscal year ending June 30, 1896, operations have continued as follows:

After awaiting a stage sufficient to get a quarter boat for use of a chopping party from Steele Bayou into Yazoo River, the U. S. snag boat *Columbia*, P. R. Starr, master, left Vicksburg January 1, 1896, took the quarter boat in tow at mouth of Steele Bayou the same day, and conveyed it to mouth of Coldwater River, which was reached January 7. The following day the *Columbia* ran down to Sharkey Landing and commenced the removal of obstructions to navigation. The stage was about 5 feet above low water; all obstructions in sight were removed, and operations extended from Sharkey to the mouth. On completion of this work, January 18, the boat started downstream, and the water being too high for effective operations in the Yazoo it returned to Vicksburg and was laid up with the fleet January 21. The master of the *Columbia* reported Tallahatchie River below Sharkey in fair navigable condition at ordinary stages, but that it should be worked over at low water to remove snags and logs on the bottom and tree slides.

The following work was done by the snag boat *Columbia* January 9–17:

Snags pulled	26
Stumps pulled	2
Shore snags cut	19
Logs removed from channel	32
Side jams removed	1
Leaning trees cut	343
Trees girdled	1,097
Square yards willows and brush cut	15

A chopping party, equipped with axes, saws, and explosives, under Overseer John Schuh, commenced work at mouth of Coldwater River January 8, 1896, and from that date to February 12 continued downstream to head of the stretch known as "The Hurricane." All snags, logs, and stumps in the channel that could be seen or located were pulled out and cut up or destroyed with explosives. Trees in the river were blown up, explosives being placed at their roots by means of poles, and the banks were cleared of leaning timber, so far as practicable. Where the timber along the banks was specially large and heavy, and of kinds that sink when green, the trees were girdled for some distance back for future removal, and to help lighten the banks and prevent slides. A tree slide, nearly in center of river, was removed at lower bend of Perkins and Jones place, and the hog-chain braces were removed from wreck of steamer *Rainey* in shallow water below Turner Place. Heavy rains the early part of February caused the river to rise, and, as there seemed little prospect of a favorable stage for some time, the force was discharged and the quarter boat laid up February 12. The water continued high during the succeeding three months, but, having reached a favorable stage, the party was reorganized May 20, after some difficulty in procuring labor at the remote place, and between that date and June 24 operations were continued downstream to Robinson Ferry, 2 miles below Sharkey.

The following is a summary of the work done by the chopping party January 8 to February 12 and May 20 to June 24, 1896, viz:

Channel snags cut and destroyed	3,043
Stumps cut and destroyed	5,248
Shore snags cut and destroyed	1,902
Logs cut and destroyed	6,459
Jams removed	5
Side jams removed	7
Leaning trees cut and destroyed	21,776
Leaning trees topped	1,153
Trees girdled	24,246
Square yards willows and brush cut	1,697

Wrecks removed: Hog-chain braces of sunken steamer *Rainey*, and 2 sunken barges.

Respecting this work, Overseer Schuh reports as follows:

The river is not navigable at low stages from Sharkey to mouth of Coldwater, but the work of the past season will enable boats to run in that stretch at stages above 6 feet with greater safety than they could last year on a 14-foot stage.

The river was badly obstructed by snags, logs, stumps, trees in the channel, overhanging the banks, and on points and in bends, the chief growth being willows, ranging from 6 to 36 inches in diameter, and ranging as far as 50 feet from the bank. In addition to general obstructions along the entire stretch, the following are worthy of special mention, viz: Two jams destroyed at Perkins & Jones place, one caused by a tree slide and the other by large snags; a jam at Turner place, caused by a caved-in tree stretching nearly across the stream; 3 side jams in the bends around Turner place, caused by caved-in trees; hog chains of steamer *Rainey* at lower end of Turner place; side jam at Dinkins place, caused by a caved-in tree; a jam 2 miles above Tillatoba Creek, caused by trees caving in from both sides and a sunken barge; a jam 1 mile above Tillatoba Creek, caused by a tree slide, and a side jam 3 miles below Possum Bayou, caused by a caved-in tree.

At present there are only 5 farms in cultivation between Sharkey and the mouth of Coldwater River, but the land is good and there is a fine growth of marketable timber, and making the stream navigable will be an inducement to settlement. The railroad is a considerable distance away, and the roads are bad, with no bridges across the sloughs, which makes hauling out of the question during continued wet weather.

The stream should be worked over again in the near future, and it would be advisable to carry operations up the Coldwater to Yazoo Pass. The Coldwater is more thickly settled than upper Tallahatchie, and there is a good trade for steamboats when they can run that far. A light snag boat like the *Columbia* could be used to advantage and the stream put in good navigable condition for small steamboats.

The appropriation of 1894 ran out June 24, and, foreseeing that the

funds would be exhausted, I submitted a project June 12 for expenditure of the appropriation by act of June 3, 1896, with recommendation that the party take advantage of the favorable conditions and continue work down to Yazoo River, but as no reply was received operations were suspended June 25–30.

Money statement.

July 1, 1895, balance unexpended	$3,643.90
Amount appropriated by act of June 3, 1896	4,000.00
	7,643.90
June 30, 1896, amount expended during fiscal year	3,629.74
July 1, 1896, balance unexpended	4,014.16
July 1, 1896, outstanding liabilities	401.17
July 1, 1896, balance available	3,612.99
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	10,000.00

COMMERCIAL STATISTICS.

The river was reported navigable to Sharkey the entire fiscal year.

List of stern-wheel steamboats navigating Tallahatchie River in fiscal year 1896.

Name.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Between—	Round trips.	Passengers.
					Light.	Loaded.			
		Feet.	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*			
E. A. Pharr	63.61	90	29.9	4.2	2 4	4 0	Greenwood and Sharkey	14	8
Ferd R*	45.5	93	16	3	1 1	3 0	do	50	20
Ed. Durant, jr.†	153.49	113.6	29.6	4.6	1 8	3 6	Greenwood and Toll's mill	1	....
							Greenwood and mouth Coldwater River, Mississippi.	2	....
Blanks Cornwall	232.4	140	29	4.6	2 2½	5 2	Vicksburg and Tallahatchie River, Mississippi.	4	63
John F. Allen*	133.9	130.2	24	4.2	1 8	4 0	do	60	221
Fifteen*	75.0	103	18	3.5	1 8	3 0	Greenwood and Sharkey	67	198

* With one or more barges. † Towboat.

Summary of commerce reported.

Articles.	1895–96.	1894–95.	1893–94.	1892–93.	1891–92.	1890–91.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Cotton	2,840	3,033	4,338	3,141	5,588	4,000
Cotton seed	6,374	6,940	7,300	4,400	8,257	6,000
Hides and skins	4	2	3	3	53	5
Live stock	45	46	30	30	31	32
Lumber	1,402	1,614	1,400	1,300	1,188	1,424
Staves	22,217	23,404	14,346	3,447	3,204	9,245
Provisions	4,200	4,800	4,700	3,450	5,571	4,200
Grain	200	6,300	6,100	1,800	5,725	4,800
Saw logs	4,600	20,000	49,500	26,700	24,473	19,000
Miscellaneous	1,690	4,800	5,100	4,100	6,329	5,000
Total	43,572	70,939	92,817	48,371	60,419	53,706
Estimated value	$1,167,000	$2,061,000	$2,372,000	$908,000	$2,428,000	$2,115,000

The Yazoo and Mississippi Valley Railroad, operated by the Illinois Central Company, has a branch line from Clarksdale to and across Tallahatchie River at Philipp, which is paralleled by a branch of the Southern Railway from Webb to Ittabena, and the Southern Railway and Illinois Central at Greenwood are competitors for the trade of Tallahatchie River.

T 11.

IMPROVEMENT OF BIG SUNFLOWER RIVER, MISSISSIPPI.

Big Sunflower River has its source in Mud Lake, Coahoma County, Mississippi, 2½ miles from Friar Point, on Mississippi River, flows in a general southerly direction, and enters Yazoo River about 45 miles above its mouth.

In accordance with requirement of river and harbor act of June 18, 1878, an examination of the river was made the latter part of that year, with a view to its improvement by the United States. At that time Clarksdale, about 180 miles above the mouth, was considered the head of the high-water navigation, and the river below that place was much obstructed by leaning timber, snags, sunken logs, sand bars, and shoals. The report upon the examination stated:

> In many places the low-water channel, being filled with logs, is of no greater depth than 18 inches, while the confining snags on either side greatly reduce the width, leaving barely sufficient room for the safe passage of the small steamers that navigate the river. These obstructions are so general throughout the entire length of the stream, and are so constantly being brought in by the sliding banks, etc., that it would be useless to attempt any description of the points at which they are to be found. At all stages the leaning trees along the banks are serious obstructions to navigation. (Report Chief of Engineers, 1879, p. 983.)

Under river and harbor act of 1879 a project was entered upon for the improvement of navigation by the removal of snags, sunken logs, and leaning timber, and by building wing dams to scour a channel 3 feet to 40 inches deep at Oliphant Bar and Muscle Shoals. Oliphant Bar begins at the mouth of the river and extends upstream 15 miles. Muscle Shoals begin about 30 miles above the mouth, and are about 5 miles long. The cost of the work, on a basis of completion in three to four consecutive seasons, was estimated at $66,000.

The appropriations have been as follows:

By act of—		By act of—	
March 3, 1879	$20,000	September 19, 1890	$5,000
June 14, 1880	8,000	July 13, 1892	5,000
March 3, 1881	4,000	August 17, 1894	5,000
August 2, 1882	5,000	June 3, 1896	5,000
July 5, 1884	5,000		
August 5, 1886	5,000	Total	72,000
August 11, 1888	5,000		

The amount expended to June 30, 1895, was $62,033.31. Work commenced in the fall of 1879. September 11 to November 27 a light-draft steamer was employed in removing snags, logs, etc., and in building wing dams at Oliphant Bar and Muscle Shoals. June 19 to December 4, 1880, work with a light steamer was continued and operations extended from the mouth to Faisonia. June 10 to September 15, 1881, a chopping party was employed in removing leaning timber, snags, etc., between Clarksdale and Faisonia, and from the latter date until October 27, 1881, in removing obstructions and building and repairing dams below Faisonia. August 26, 1882, to January 30, 1883, a chopping party worked from Standing Stump up to Clarksdale. October 12 to December 21, 1884, a light-draft steamboat was employed in the lower river, removing snags, logs, etc., and building and repairing wing dams. This work was supplemented by operations of the U. S. snag boat *Meigs*, January 1 to 18, 1885. June 14 to August 26, 1887, operations below Faisonia were continued with a light draft steamer and a force of 25 to 30 laborers, removing obstructions in the channel and building wing dams at the shoals. June 7 to July 7 and September 1 to 9, 1889, a steamboat was employed in going over the work below Faisonia, removing

obstructions and building and repairing dams. January 10 to February 13, 1891, the U. S. snag boat *Meigs* was employed in the river below Faisonia, but withdrawn the latter date on account of high water. June 1 to 30, 1891, the U. S. snag boat *Florence* operated between the mouth and a point 18 miles above Faisonia, and August 18 to 30, 1891, the *Florence* worked to Faisonia again. January 31 to March 25, 1893, the snag boat *Meigs* worked over the river from its mouth to Faisonia, removing a large number of obstructions. No work was done in the fiscal years 1894 and 1895.

From the above summary it will be seen that from 1879 to 1893 operations extended over the navigable part of the river, from Clarksdale to its mouth, but that little was done above Faisonia after 1882. In the first three years, from 1879 to 1882, $37,000 were appropriated, and fairly good progress is said to have been made. In the succeeding twelve years only $30,000 were provided, by biennial appropriations of $5,000, for continuing the improvement. New obstructions were added each year, and on this account little or no progress was made. It has been the endeavor to keep the lower river open to navigation, with a view to extending the limits upstream should sufficient funds be provided. Before work commenced there was navigation for light boats about six months of the year. At the close of operations in 1893 the lower river was navigable the year round, but passage was difficult and dangerous at low stages on account of shoals, snags, and sunken logs. Boats made trips at ordinary stages in little more than half the time formerly required, and freight rates were said to be 50 per cent less. Faisonia, about 100 miles above the mouth, was considered the head of navigation, and boats ran to Woodburn, 77 miles above the mouth, the year round.

Operations during the fiscal year ending June 30, 1896, were as follows:

Work under the appropriation of 1894 had been delayed for lack of plant. A boat of light draft and with sufficient power to remove snags and logs in the channel was needed, but the amount available was too small for construction or hire of a suitable vessel, and none was available at the time from the district plant. The *Columbia*, the lightest snag boat of the district, which had been overhauled and repaired, was fitted out for operations, left Vicksburg September 22, 1895, P. R. Starr master, and entered Big Sunflower River the following day, where it was employed until December 13, 1895.

During that period the river was at an extreme low stage, said to have been about 6 inches below the lowest previously known, and progress upstream was slow and difficult. At the crossings on Oliphant Bar depth ranged from 14 to 20 inches, but by building wing dams at frequent intervals, of brush and with sacks of earth, the flow was concentrated and channel scoured to a depth of 26 to 30 inches. Logs and snags in the channel, projecting shore snags, leaning timber, and stumps along the banks were removed. In the stretch known to local steamboat men as "The Hurricane," the river was narrow and shoal, with the channel close in shore, and logs, etc., were numerous. At Muscle Shoals but 16 inches depth was found, but, by means of wing dams, it was increased to 26 to 28 inches. These shoals consist of a layer of hard blue clay, shells, and sand, covered with a long tough moss, overlying clear, sharp sand which scours rapidly when the upper crust is broken. From "Head of Drift" up to near Callao the river was wide and deep, with but few obstructions in the channel. At Callao and Osceola the least depth found was 28 inches, but between the two places the channel was crooked and overgrown with a water plant called "buck moss,"

so thick and tenacious that the boat could not be steered through it without the aid of poles. From Osceola to New Berlin there was good navigable depth, but obstructions were numerous, and above New Berlin to Hollywood the channel was full of snags and logs. Hollywood, about 70 miles above the mouth, was reached November 30, and only 12 to 15 inches depth was found on the shoal at that place. The available funds being nearly exhausted the *Columbia* turned back, removed snags, logs, etc., on the way down, and closed a chute to concentrate the flow at Maybin Island. The boat reached the mouth of the river December 12, and returned to Vicksburg the following day.

The following is a summary of the work done, viz:

Number of miles worked over	70
Snags pulled and blown up	179
Logs removed from channel	811
Stumps pulled and blown up	159
Shore snags cut	1,842
Leaning trees cut	16,599
Trees girdled	5,356
Willows and brush cut ..... square yards	5,463
Side jams removed	2
Wing dams built, aggregating 1,810 feet in length	23
Old dams repaired	1

This work, so far as it extended, put the river in fair navigable condition for the time, and, notwithstanding the exceptionally low stage, small boats resumed trips to Callao as soon as operations had been carried to that place.

Attention is invited to the following extract from my report of 1891, repeated each year since, viz:

> The estimate of $66,000, made in 1879, for the improvement of this river (p. 984, Report Chief of Engineers, 1879), did not contemplate doing the work at irregular intervals extending over a period of fifteen years, as it will with the usual appropriations, but was made with a view to finishing it in not more than three or four consecutive seasons. As new obstructions are added from time to time it is impossible to make any definite estimate, but if an appropriation of not less than $20,000 is made it can be spent to advantage and with economy in one or two low-water seasons and result in greater benefit to navigation and work of a more lasting character than a larger sum by small allotments every other year.

A preliminary examination of this river, with a view to its improvement as high as Clarksdale by locks and dams, was required by river and harbor act of August 17, 1894, and the report thereon was submitted April 4, 1896. (See Appendix T 13.)

Money statement.

July 1, 1895, balance unexpended	$4,966.69
Amount appropriated by act of June 3, 1896	5,000.00
	9,966.69
June 30, 1896, amount expended during fiscal year	4,966.69
July 1, 1896, balance unexpended	5,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	20,000.00

COMMERCIAL STATISTICS.

The river was reported navigable in the fiscal year as follows: During July, and October 1 to December 31, 1895, Callao was the head of low-water navigation. From January 1 to June 30, 1896, there was navigation for the regular packets to Faisonia. From March 7 to 21, 1896, there was navigation to Lehrton, the present head of high-water navigation.

List of steamboats that navigated Big Sunflower River in the fiscal year.

Name.	Class.	Tonnage.	Length.	Breadth.	Depth.	Draft.		Between—	Round trips.	Passengers.
						Light.	Loaded.			
			Feet.	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*			
Novelty	Stern-wheel.	63.40	76.4	16.4	3	1 3	3 6	Vicksburg and Lehrton.	2	10
								Vicksburg and Woodburn.	24	105
Atlanta	...do ..	85.03	93	16.4	3.7	2 0	3 6	Vicksburg and Callao	1	5
								Vicksburg and Woodburn.	1	5
Lake Palmyra	...do ..	141	123.5	26	4.8	2 6	5 10	Vicksburg and Lehrton.	2	....
								Vicksburg and Faisonia.	12	126
								Campbellsville and Woodburn.		
								Vicksburg and Woodburn.	3	....
Mary Joyce*	...do ..	34.64	65	14	2.4	1 1	2 0	Vicksburg and Baird.	1	....
Mima*	...do ..	62.72	66	17	3.2	1 2	2 6	Vicksburg and Big Sunflower River.	1	....
Laurens	.....	.....	.....	.....	.....	.....	.....	New Orleans and Big Sunflower River.	1	....
Yazonia*	Stern-wheel.	62.84	95	19.8	3.5	1 3	3 6	Yazoo City and Campbellsville.	19	176
Fifteen*	...do ..	75	103	18	3.5	1 8	3 0	.....do	12	113
Hibernia	...do ..	157.06	135	25	4	2 6	4 0	Vicksburg and Campbellsville.	15	247
Maggie*	...do ..	50.73	85	19	3.5	1 3	3 0	Yazoo City and Campbellsville.	40	428
Joe Seay*	Tug...	27.74	75	16	7	6 0	7 6	Vicksburg and Gumwood.	2	....
Thos. A. Hendricks†	Stern-wheel.	81.86	108	22.5	4.2	4 2	5 0	Vicksburg and Callao	1	....

* With one or more barges. † Towboats.

Summary of commerce reported.

Articles.	1895–96.	1894–95.	1893–94.	1892–93.	1891–92.	1890–91.	1889–90.	1888–89.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Cotton	2,050	3,601	2,400	2,699	4,118	2,375	2,594	4,000
Cotton seed	5,407	5,760	5,700	5,250	5,450	3,500	3,975	6,000
Hides	17	24	12	19	12	.....	.....	1
Live stock	80	71	38	250	265	70	150	150
Saw logs	1,209	2,475	5,650	19,000	21,835	15,400	4,000	.....
Lumber	557	1,500	780	1,130	906	920	869	.....
Staves	17,805	8,105	9,405	9,840	4,430	3,219	5,250	490
Miscellaneous	9,372	375	2,050	1,088	2,549	2,027	.....	3,880
Total down freight	36,488	21,911	26,035	39,276	39,565	27,511	16,838	14,521
Return freight	2,380	2,623	4,285	4,023	7,489	4,473	5,322	9,680
Total	38,868	24,534	30,320	43,299	47,054	31,984	22,160	24,201
Estimated value	$783,000	$956,000	$988,000	$893,000	$1,354,000	$945,000	$1,240,000	$1,858,000

The Yazoo and Mississippi Valley Railroad crosses the river at Clarksdale and thence runs south parallel to the stream at distances varying from 5 to 20 miles. The Georgia Pacific (Sixth) Division of the Southern Railway crosses the river at Baird with a line running from Greenville, on the Mississippi River, to Atlanta, Ga.

T 12.

WATER GAUGES ON THE MISSISSIPPI RIVER AND ITS PRINCIPAL TRIBUTARIES.

These gauges were designed to secure information from continuous records with a view to protecting alluvial lands against overflow, improvement of navigation, and giving correct reports of stages of

water for the benefit of river men and planters. Their establishment and maintenance were directed by joint resolution of Congress, approved February 21, 1871 (sec. 5252, Rev. Stat.), viz:

SEC. 5252. The Secretary of War is hereby authorized and directed to have water gauges established and daily observations made of the rise and fall of the Lower Mississippi River and its chief tributaries at or in the vicinity of St. Louis, Cairo, Memphis, Helena, Napoleon, Providence, Vicksburg, Red River Landing, Baton Rouge, and Carrollton, on the Mississippi, between the mouth of the Missouri and the Gulf of Mexico; and at or in the vicinity of Fort Leavenworth, on the Missouri; Rock Island, on the Upper Mississippi; Louisville on the Ohio; Florence, on the Tennessee; Jacksonport, on the White River; Little Rock, on the Arkansas, and Alexandria, on the Red River, and at such other places as the Secretary of War may deem advisable. The expenditure for the same shall be made from the appropriation for the improvement of rivers and harbors, but the annual cost of the observations shall not exceed the sum of five thousand dollars.

From the first it was evident that the sum of $5,000 was not sufficient to cover the annual expenses of observations, repairs, and frequent inspections essential to accuracy, and after the appropriations for rivers and harbors became biennial various expedients were resorted to to maintain the service. In 1878 observations were stopped for want of funds, but many observers continued the records without compensation; in 1884 a deficiency appropriation was required for their continuance; in 1886 the Mississippi River Commission paid the observers and repaired and inspected the gauges on the Mississippi to prevent suspensions, and in 1887–88 readings were continued voluntarily by the observers. It was seen by that time that the work should cease unless means were provided for maintaining the gauges, and the river and harbor act of August 11, 1888, granted a permanent indefinite appropriation for the purpose as follows:

SEC. 6. That for the purpose of securing the uninterrupted gauging of the waters of the Lower Mississippi River and its tributaries, as provided for in joint resolution of the twenty-first of February, eighteen hundred and seventy-one, upon the application of the Chief of Engineers, the Secretary of War is hereby authorized to draw his warrant or requisition from time to time upon the Secretary of the Treasury for such sums as may be necessary to do such work, not to exceed in the aggregate for each year the amount appropriated in this act for such purpose: *Provided, however*, That an itemized statement of said expenses shall accompany the Annual Report of the Chief of Engineers.

The amount appropriated in the act of August 11, 1888, was—

For gauging the waters of the Lower Mississippi River and its tributaries, as provided for in joint resolution of twenty-first of February, eighteen hundred and seventy-one, nine thousand six hundred dollars: *Provided*, That three thousand six hundred dollars of same is authorized to be expended in paying the expenses of gauging the said waters during the fiscal year ending June thirtieth, eighteen hundred and eighty-eight.

The same act, in the item of appropriation for continuing operations upon the reservoirs at the headwaters of the Mississippi River, provided as follows:

And the Secretary of War shall cause such gaugings to be made at or near St. Paul during the annual operation of said reservoirs as shall determine accurately the discharge at that point, the cost of same to be paid out of the annual appropriation for gauging the waters of the Mississippi River and its tributaries.

Although the act of 1888 provided an annual appropriation not to exceed $9,600, and while that amount was allotted for the fiscal years 1889, 1890, and 1891, a ruling was made in April, 1891, that only $6,000 should be drawn from the Treasury each fiscal year. In consequence of that ruling observations at a large number of gauges during the last quarter of the fiscal year 1891 were paid for from appropriations for works benefited by maintaining the records, as the balance in hand was not sufficient for the purpose.

The appropriations and allotments for this work have been as follows:

Allotments from general appropriations for examinations, surveys, and contingencies of rivers and harbors by acts of—	
March 3, 1871	$5,000
June 10, 1872	5,000
March 3, 1873	5,000
June 23, 1874	5,000
March 3, 1875	5,000
Specific appropriations by river and harbor acts of—	
August 14, 1876	5,000
June 18, 1878	5,000
March 3, 1879	5,000
June 14, 1880	5,000
March 3, 1881	5,000
August 2, 1882	5,000
Deficiency act of March 12, 1884	2,100
Specific appropriations by river and harbor acts of—	
July 5, 1884	5,000
August 5, 1886	5,000
Allotted from specific appropriation by river and harbor act of August 11, 1888	8,700
Deficiency act of October 19, 1888	3,600
Allotments from permanent appropriation made by section 6 of river and harbor act of August 11, 1888, for fiscal years, viz:	
1890	9,000
1891	8,700
1892	5,100
1893	5,500
1894	5,500
1895	5,500
1896	5,500
Total	124,200

The following statement shows the disposition of the funds apportioned to this work:

Amount expended to June 30, 1896	$114,087.88
Amount of deficiency appropriation of October 19, 1888, not used	3,600.00
Balance of appropriation by act of August 11, 1888, not expended	1,566.29
Balance of allotment for fiscal year 1890, not expended	1,281.66
Portion of allotment for fiscal year 1891, withheld at United States Treasury under ruling that only $6,000 can be drawn each fiscal year	3,518.34
Balance unexpended July 1, 1896	145.83
Total, as above	124,200.00

Prior to 1892 it was held that the balance of an allotment unexpended at the close of a fiscal year could not be used in addition to the allotment for a succeeding year, but July 13, 1892, the Secretary of the Treasury decided that allotments under section 6 of the act of August 11, 1888, were "no limit" appropriations.

The gauges ordered by the resolution of February 21, 1871, were established the latter part of that year, except the one at Carrollton, La., established in January, 1872. A gauge was placed at the mouth of White River instead of Napoleon, Ark., as the latter place was caving into the river. Two gauges were established at Louisville, Ky., one at head and one at foot of the falls, and at request of the steamboat interest, a gauge was set up at Natchez, Miss. In August, 1873, a gauge was established at Nashville, Tenn., on Cumberland River. In February, 1890, gauges were established on Red River at Shreveport, La., and Garland and Fulton, Ark., and the one at Donaldsonville, La., on the Mississippi, was established in June, 1890.

The gauge at Rock Island, Ill., was discontinued April 30, 1879, and the gauge at Fort Leavenworth, Kans., was abandoned November 30, 1886. Readings at the latter place have been continued by the Missouri River Commission.

Observations at each station commenced when the gauge was set up, and with few exceptions, during periods when no funds were available, have continued regularly since. In 1881 bulletins were erected on the Mississippi to give passing steamboats the stage of water at each reading, and show whether rising, stationary, or falling. The plates in the original bulletins were $20\frac{3}{4}$ by 24 inches, black figures on white ground, but in 1890 they were replaced by larger bulletins, one-sixteenth inch sheet-iron plates, 40 by 48 inches, white figures on black ground, large enough to be read easily with the naked eye at a distance of half a mile. The old bulletins were repaired and used in extending the service to the tributaries. From 1871 to February 1, 1887, the gauges were read and bulletins changed at 8 a. m. daily. Since the latter date this has been done at 8 a. m. and 4 p. m. every day, and greater uniformity and accuracy have been secured by the change. Gauge readings are received at this office weekly and are reviewed, consolidated, and sent to the secretary of the Mississippi River Commission, by whom they have been published to the end of the calendar year 1895.

Gauge staves are made in advance at Vicksburg and shipped when needed, a few sections being kept on hand at stations with caving banks or where the gauge must be set in an exposed place. They are of two sizes, the larger to be bolted to bridges, wharves, etc., and the smaller, for temporary service, to be driven into the bank at successive stages, rising or falling. Numbers and graduations in feet and tenths are branded, thus saving time and money, giving uniform scales, and marks not easily obliterated.

The Engineer gauges are used by the Weather Bureau at St. Louis, Mo., Cairo, Ill., Memphis, Tenn., Helena, Ark., Vicksburg, Miss., Donaldsonville, La., Florence, Ala., Nashville, Tenn., Alexandria, La., Shreveport, La., and Fulton, Ark.

The present service consists of twenty-two gauges, at which observations were continued during the fiscal year ending June 30, 1896, viz: On Mississippi River, at St. Louis, Mo., Cairo, Ill., Memphis, Tenn., Helena, Ark., mouth of the White River, Arkansas, Lake Providence, Louisiana, Vicksburg, Miss., Natchez, Miss., Red River Landing, La., Baton Rouge, La., Donaldsonville, La., and Carrollton (New Orleans), La.; on Ohio River, at Louisville, Ky., head of falls and foot of falls; on Tennessee River, at Florence, Ala.; on Cumberland River, at Nashville, Tenn.; on White River, at Jacksonport, Ark.; on Arkansas River, at Little Rock, Ark.; and on Red River, at Alexandria and Shreveport, La., and Garland and Fulton, Ark.

Records of the daily readings were furnished the secretary of the Mississippi River Commission; copy of the Florence record was furnished the engineer officer in charge of Tennessee River; copy of the Carrollton record was sent the assistant engineer at South Pass of the Mississippi; copy of the Jacksonport record was sent the chief engineer of the Mississippi Levee Commisioners; and district officers, levee commissioners, etc., were furnished copies of records upon application.

The following gauges were inspected during the year by Asst. Engineer John Ewens, viz:

September.—(26th) Natchez, Miss., gauge rebuilt from —1 to 15 foot mark; (29th) Red River Landing, La., gauge rebuilt from 1 to 42.5 foot mark; (30th) Baton Rouge, La., gauge rebuilt from —1 to 38 foot mark.

October.—(2d) Donaldsonville, La., gauge rebuilt from —0.5 to 29 foot mark; (4th) Carrollton, La., gauge rebuilt from —2 to 19 foot mark; (8th) Lake Providence, Louisiana, gauge rebuilt from —4 to 44.5 foot mark; (12th) mouth of White River, Arkansas, gauge rebuilt from —1 to 51.2 foot mark; (14th) Helena, Ark., gauge rebuilt from —4 to 52 foot mark; (17th) Memphis, Tenn., gauge rebuilt from —3 to 22.9 foot mark; (21st) Cairo, Ill.; (28th) St. Louis, Mo.

November.—(12th) Natchez, Miss., gauge rebuilt from —4 to 51 foot mark; (21st) Vicksburg, Miss., gauge rebuilt from —7 to 8 foot mark.
December.—(27th) Vicksburg, Miss., gauge rebuilt from 6 to 30 foot mark.

Comparison of highest water of fiscal year 1896 with highest previously recorded since establishment of present gauges.

Gauge stations.	Year gauge was established.	Elevation of gauge zero above Cairo datum plane.	Elevation of gauge zero above mean Gulf level at Biloxi, Miss.*	Highest water previously recorded on present gauge.		Highest water during fiscal year ending June 30, 1896.		Relation to previous highest record.
				Date.	Gauge reading.	Date.	Gauge reading.	Below.
		Feet.	*Feet.*		*Feet.*		*Feet.*	*Feet.*
St. Louis, Mo	1871	400.23	378.97	May 19, 1892	35.95	May 26, 28	27.70	8.25
Cairo, Ill	1871	290.84	269.58	Feb. 27, 1883	52.17	Apr. 13	39.20	12.97
Memphis, Tenn	1871	203.97	182.71	Mar. 23, 24, Apr. 4, 5, 1890.	35.60	Apr. 15, 16	29.40	6.20
Helena, Ark	1871	161.98	140.72	Apr. 30, 1886	48.10	Apr. 17	38.42	9.68
Mouth White River, Ark	1871	128.73	107.47	Mar. 31, 1890	50.40	Apr. 18	41.72	8 68
Lake Providence, La	1871	89.62	68.36	June 2, 1892	41.90	Apr. 20, 21	33.25	8.65
Vicksburg, Miss	1871	66.04	44.78	Apr. 24, 25, 1890	49.05	Apr. 21	39	10.05
Natchez, Miss	1871	36.89	15.63	Apr. 23, 1890	48.60	Apr. 22	38.35	10.25
Red River Landing, La.	1871	23.85	2.59	June 27, 1892	48.87	Apr. 22, 23	37.40	11.47
Baton Rouge, La	1871	20.06	—1.20	June 28, 1892	38.45	Apr. 23, 24	28.85	9.60
Donaldsonville, La	1890	†19.14	†2.12	June 23, 1893	30.60	Apr. 23, 24	23.05	7.55
Carrollton, La	1872	20.91	—0.35	June 22, 1893	17.45	Apr. 24	13.70	3.75
Louisville, Ky. (upper)	1871	†419.76	†398.50	Feb. 16, 1884	46.60	Apr. 5	22.40	24.20
Louisville, Ky. (lower)	1871	†392.85	†371.59	Feb. 16, 1884	72	Apr. 5	47.80	24.20
Florence, Ala	1871	†418.03	†396.77	Jan. 22, 1882	29.60	Apr. 9	20	9 60
Nashville, Tenn	1873	.....	.....	Jan. 22, 1882	55.30	Apr. 7	42.90	12.40
Jacksonport, Ark	1871	.....	.....	Mar. 14, 1890	33.35	Dec. 24	30.00	3.35
Little Rock, Ark	1871	241.50	220.24	May 21, 1892	31.20	Dec. 27	25.80	5.40
Alexandria, La	1871	64.46	43.20	June 12, 13, 1892	38.25	Aug. 5	28.20	10.05
Shreveport, La	1890	161.27	140.01	May 28, 1892	35.70	July 29, 30	30.30	5.40
Garland, Ark	1890	223.44	202.18	Mar. 24, 1894	28.50	July 19	28.38	.12
Fulton, Ark	1890	244.78	223.52	May 23, 24, 1892	34.85	July 18	31.55	3.30

*Mississippi River Commission preliminary value, 21.26 feet above Cairo datum plane.
†Preliminary value.

Comparison of lowest water of fiscal year 1896 with lowest previously recorded since establishment of present gauges.

Gauge stations.	Year gauge was established.	Lowest water previously recorded on present gauge.		Lowest water during fiscal year ending June 30, 1896.		Relation to previous lowest record.	
		Date.	Gauge reading.	Date.	Gauge reading.	Above.	Below.
			Feet.		*Feet.*	*Feet.*	*Feet.*
St. Louis, Mo	1871	Jan. 13, 1895	—0.80	Dec. 9	—0.15	0.65	.....
Cairo, Ill	1871	Dec. 24, 1871	—1	Nov. 6	1.10	2.10	.....
Memphis, Tenn	1871	Nov. 6–8, 1894	—1.40	Nov. 6–9	—2.65	.....	1.25
Helena, Ark	1871	Nov. 8, 1894	—2.23	Nov. 8, 9	—3	.....	.77
Mouth White River, Ark.	1871	Dec. 28, 1872	0	Nov. 8–10	1.28	1.28	.....
Lake Providence, La	1871	Nov. 9, 11, 12, 1894	—4.25	Nov. 17	—5.30	.....	1.05
Vicksburg, Miss	1871	Nov. 11–14, 1894	—5.31	Nov. 13, 14	—6.53	.....	1.22
Natchez, Miss	1871	Dec. 14, 15, 1872	0	Nov. 13–15	— .85	.....	.85
Red River Landing, La.	1871	Nov. 12, 1894	— .25	Nov. 14	— .60	.....	.35
Baton Rouge, La	1871	Nov. 14, 1894	.45	Nov. 16	.80	.35	.....
Donaldsonville, La	1890	Nov. 11, 1894	1	Nov. 30	1.25	.25	.....
Carrollton, La	1872	Dec. 27, 1872	—1.60	Nov. 9, 10, 12, 22, 24, and Dec. 23.	.05	1.65	.....
Louisville, Ky. (upper)	1871	Sept. 10–14, 18–22, 1881	1.70	Nov. 14–16	1.70	.....	.....
Louisville, Ky. (lower)	1871	Oct. 17, 18, 1872	1.60	Oct. 19–27, and Nov. 6–8.	2	.40	.....
Florence, Ala	1871	Sept. 18, 1878	— .76	Oct. 13, 14, 27–30	0	.76	.....
Nashville, Tenn	1873	Oct. 15, 16, 1878	— .40	Oct. 29, 30	.10	.50	.....
Jacksonport, Ark	1871	Dec. 24, 1872	—1.10	Nov. 5–7	.35	1.45	.....
Little Rock, Ark	1871	Oct. 23, 24, 1879	—1	Nov. 6–11	3.50	4.50	.....
Alexandria, La	1871	Sept. 29, 1881	—3.70	Nov. 19	—1.90	1.80	.....
Shreveport, La	1890	Dec. 2–4, 1894	—5.50	Oct. 19	—3.70	1.80	.....
Garland, Ark	1890	Nov. 30–Dec. 2, 1894	1.10	June 30	1.20	.10	.....
Fulton, Ark	1890	Nov. 27–Dec. 7, 1894	2.85	June 20–30	1.40	.....	1.45

Itemized statement of expenditures during the fiscal year ending June 30, 1896, submitted in compliance with requirements of section 6 of river and harbor act of 1888.

Observations:		
Pay of 20 permanent gauge keepers from July 1, 1895, to June 30, 1896, inclusive	$3,540.00	
Paid widow of deceased gauge keeper, Memphis, Tenn., for services July 1–September 7, 1895	33.50	
Pay of gauge keeper, Memphis, Tenn., for services October 17, 1895–June 30, 1896	127.00	
		$3,700.50
Inspections and repairs:		
Pay of assistant engineer, six months and five days, at $150 per month	925.00	
Traveling expenses of assistant engineer while inspecting gauges	150.15	
Pay of employees hired to assist gauge inspector and to repair gauges and bulletins	29.50	
Material for repair of gauges	166.60	
Transportation of material for repair of gauges	6.71	
New bulletin frame for gauge at mouth of White River, Arkansas	48.28	
Charcoal for heating brands for marking gauges	1.20	
		1,327.44
Office expenses and contingencies:		
Pay of clerk, three months, at $100 per month	300.00	
Stationery	23.25	
Index case	3.00	
		326.25
Total		5,354.19

Money statement.

July 1, 1895, balance unexpended	$0.02
Amount allotted for fiscal year ending June 30, 1896	5,500.00
	5,500.02
June 30, 1896, amount expended during fiscal year	5,354.19
July 1, 1896, balance unexpended	145.83
Amount allotted for fiscal year ending June 30, 1897	5,500.00
July 1, 1896, amount available	5,645.83
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	12,000.00

T 13.

PRELIMINARY EXAMINATION OF BIG SUNFLOWER RIVER, MISSISSIPPI, WITH A VIEW TO ITS IMPROVEMENT AS HIGH AS CLARKSDALE BY LOCKS AND DAMS.

[Printed in Senate Doc. No. 245, Fifty-fourth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., May 4, 1896.

SIR: I have the honor to submit the accompanying copy of report, dated the 4th ultimo, by Maj. J. H. Willard, Corps of Engineers, respecting a preliminary examination of Big Sunflower River, Mississippi, with a view to its improvement as high as Clarksdale by locks and dams, made to comply with the provisions of the river and harbor act of August 17, 1894.

For reasons stated, Major Willard is of the opinion that the Big Sunflower River is worthy of improvement to a greater extent than has yet been authorized, and that the cost of a survey required for the preparation of a project for increasing the scope of improvement as an open river would be $10,000, but that this river alone is not worthy of improvement by the United States by locks and dams at the present time; although if considered as a part of a system of internal navigation, to be formed by locks and dams, it might be worthy of improvement in the same way, the extension depending upon the development of its valley, and eventually, probably, as high as Clarksdale.

He is also of the opinion that an exhaustive survey, at a cost of not less than $50,000, of the streams of the Yazoo Basin should be undertaken, for the purpose of ascertaining the feasibility and cost of a system of locks and dams in said basin, and that such survey is a public necessity.

Col. J. W. Barlow, Corps of Engineers, Division Engineer, concurs in the views of Major Willard respecting a comprehensive survey of the Yazoo system.

In my opinion, which the law requires me to express, the improvement of the Big Sunflower River as high as Clarksdale by locks and dams should not be undertaken by the United States at this time.

Very respectfully, your obedient servant,

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

Hon. DANIEL S. LAMONT,
Secretary of War.

REPORT OF MAJ. J. H. WILLARD, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., April 4, 1896.

GENERAL: In compliance with instructions contained in letter from your office, dated August 20, 1894, I have the honor to submit this report upon "Big Sunflower River, Mississippi, with a view to its improvement as high as Clarksdale by locks and dams," the preliminary examination of which was called for by section 10 of river and harbor act of August 17, 1894.

Big Sunflower River was examined under Major Benyaurd late in 1878, in accordance with a provision in the act of June 18, 1878. Owing to the outbreak of yellow fever in this valley, and to other circumstances, the examination was hasty and incomplete. No reports, maps, or sketches are on file in this office, and it is inferred that none were made, owing to the disturbed condition of this part of the country.

The general character of the alluvial streams in this district indicated the same general plan for preliminary improvement, viz, clearing the banks of leaning timber, removing snags, logs, and other obstructions from the channel, etc.; and the knowledge of the existence of certain shoals suggested closing chutes and building inexpensive wing dams. Major Benyaurd's project contemplated work during three or four successive low-water seasons at an estimated expenditure of $66,000. Congress has appropriated $67,000, from March 3, 1879, to August 17, 1894, but this amount, spread over seventeen years, has not accomplished what was hoped for when the estimate was submitted, nor given complete satisfaction to those interested in navigation,

although the improvement has been considerable in giving a longer period of navigation each season and materially lessening its dangers. Major Benyaurd's opinion was that radical improvement of Big Sunflower River should be postponed, and attention paid chiefly to the immediate needs of commerce, an opinion fully justified by reference to the conditions existing at that time. Then there was no levee system. Existing levees were independent, low grade, and broken, and the whole Yazoo Delta was overflowed by every great high water from above Clarksdale to Vicksburg, with the exception of a narrow strip between Clarksdale and Tallahatchee River to a point a few miles below Greenwood on Yazoo River. The alluvial map of Mississippi Valley, published by the Mississippi River Commission, illustrates this in a striking way.

Now this great basin is entirely free from overflow in its upper part, and subject only to backwater up Yazoo River, depending upon the elevation of flood water at the limit of the Yazoo Front at Brunswick, a few miles above Vicksburg.

When the call for this examination came there was practically no definite information on file in this office except that which had been obtained incidentally while prosecuting other work.

In 1858 a line of levels had been run under the Delta survey from Greenwood on Yazoo to Prentiss on Mississippi River, but no permanent benches were made, so that the section gives only a notion of relative elevations. In 1879 a section was made under the Mississippi River Commission from Lake Providence to Yazoo City, which has been tied in by connecting the benches at each end with the system of precise levels of the Coast Survey and Engineer Department.

In developing the survey for the project for diverting Yazoo River and improving Vicksburg Harbor a loop of precise levels had been finished from Vicksburg to Yazoo City and from Greenville to Greenwood, and thence to Yazoo City, the line of the United States Coast Survey closing between Vicksburg and Greenville, by which we were able to get elevations on Sunflower River at Baird, Georgia Pacific Railroad Bridge, and at L'Argent, the junction of Big Sunflower with Yazoo. In order to get elevations at Clarksdale a line of precise levels was run from Mississippi River Commission benches at Friar Point to Yazoo and Mississippi Valley Railway Bridge across Big Sunflower near Clarksdale. Maps were then compiled from such county maps as could be found, supplemented by a tracing of land-survey maps at the State capitol, Jackson, Miss. With this foundation Assistant Engineer Marshall made the field reconnoissance in February, 1896, using an improvised plane table in the pilot house of one of the small snag boats, a method that had been tried with considerable success on Ouachita River. The maps* have been adjusted on eleven sheets, scale 1: 10,000, by comparison with those of the land surveys, and give a very fair representation of the general course and windings of the river. With them is a combined hydrograph* of Big Sunflower and Yazoo rivers from definite information obtained by levels to Clarksdale, Baird, and L'Argent for Big Sunflower, and at a greater number of points on Yazoo.

This hydrograph is interesting as showing the protection due to the levees on Yazoo Front, but its value is quite limited for discussing improvement of Big Sunflower River by means of locks and dams. It has a value of its own, however, in this that it indicates the probability that each stream of what I may call the Yazoo System should carry its

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* Not submitted.

own water hereafter and be free from dangerous floods so long as the levees on Yazoo Front shall stand.

As already suggested, conditions have changed immensely since the first examination of Big Sunflower River in 1878, and it would be difficult to find another portion of country of like area where improvement and development have been so marked. By the cooperation of the river commission, State levee commissions, and the Yazoo and Mississippi Valley Railway Company a basin some 200 miles long by about 60 miles broad at its widest part has been secured against overflow. The lands so reclaimed are the most fertile in the Mississippi Valley, and capable of sustaining a large population. The country is being settled rapidly, especially by small farmers, colored as well as white, and by not a few colonists from Northern States.

The Illinois Central bounds this basin on east and west, and branches are being extended into the interior from both divisions where the Georgia Pacific division of the Southern Railway crosses it from Greenville on Mississippi River to Greenwood on the Yazoo. But the people want the natural routes improved, and transportation assured the year round, especially those who live in the secondary valleys or river bottoms, who find the long hauls from their farms to railway stations a heavy burden even when the country roads are in fair condition, and who feel that an assured river trade would benefit all by equalizing and moderating freight charges.

The hydrograph shows what the general gain has been, but figures give concrete ideas, and accordingly the following table has been made showing the "protection," that is, the difference between overflow high water from Mississippi River and natural high water on Big Sunflower and Yazoo rivers since the levee system has been inaugurated. Elevations in this engineering district are in the metric system, and refer to an arbitrary plane known as Cairo datum.

	Meters.	Feet.
Big Sunflower:		
Clarksdale	11.3	=36.2
Baird	7.6	=24.9
Yazoo River:		
Greenwood	3.50	=11.5
Yazoo City	3.47	=11.4

The gain in Big Sunflower Valley obviously should be greater than in Yazoo Valley, for Yazoo River skirts the hills bounding this great basin on the east and receives the rains quickly on the one hand, while on the other it was subject to Mississippi floods, either from above through Tallahatchie River or across the basin, only after all the intermediate valleys had been filled. Of course the immense range at Clarksdale was due to the flow through the historic Hushpucana.

The hydrograph also indicates that natural high water should be within banks, as a rule, and therefore that a system of slack-water navigation should not be dangerous to the inhabitants of the valley, especially if movable dams were employed, to be lowered on the approach of a flood wave, and to be thrown down at stages high enough for open navigation.

The revival of interest in the American bear trap and its recent improvements gives grounds for believing that this form of dam should be peculiarly fitted for streams of small low-water discharge, and especially for Big Sunflower River, which differs from all other streams in this basin in that it is comparatively free from drift and is a clear-water stream, being fed chiefly by springs and filtration. The question of foundations should not be regarded as a serious one in the light of

modern experience. There is a lock of cut stone at Kampsville, on Illinois River, 375 feet long by 75 feet wide by 7 feet lift, with a fixed dam 1,200 feet long on an alluvial foundation inclosed and confined by sheet piling, and therefore I have no doubt that smaller constructions may be built with safety on Big Sunflower River, although the cost would be somewhat large.

There are other considerations, however, that would demand close attention and which indicate the need of an exhaustive survey of the whole valley. The streams in this basin interlace and connect through creeks, bayous, and lakes, and unless due care were taken in locating a dam or in closing outlets the effect of a pool might be to flank and abandon a lock and dam and make a new channel into one of the side streams. Big Sunflower River connects with Yazoo through Lake George, Silver Creek on the eastward, and with Rolling Fork, Little Sunflower, and Deer Creek, and so around again to Yazoo below. The drainage and discharge of Big Sunflower with respect to Yazoo River is such that at times, when the latter is rising, there is a strong current of backwater felt for miles up Big Sunflower, so that the first lock would require guard gates if placed in Big Sunflower River, or else the lock and dam would have to be placed in Yazoo River below L'Argent. The latter plan would have the merit of giving slack water in each stream in the inverse ratio of their slopes, while obviating the danger of flanking from the first pool into Yazoo through connections from the left or eastward bank of Big Sunflower.

The main question, then, may be answered in the affirmative; it is feasible to improve Big Sunflower River as high as Clarksdale by locks and dams.

The number of dams would depend upon the lifts that could be given with safety and upon the relative elevations of the pools formed by them with respect to the banks and to the connections with other streams in the basin. Assuming that the interests of navigation would not be satisfied with less than 1 meter, say 3 feet, above low water at Clarksdale, the levels indicate at least nine dams, with an average lift of about $2\frac{1}{2}$ meters (about 8 feet), and that the first dam, as already suggested, would have to be put in Yazoo River below the mouth of Big Sunflower.

The cost of such a system would be large, and the annual charges for maintenance and operation probably would exceed the amount that has been spent for improving Big Sunflower since Congress first authorized the work.

From the commercial statistics it appears that the business on Big Sunflower River during the fiscal year 1895 amounted to about 24,000 tons, valued at about $950,000. How great the increase would be from the inauguration of slack-water navigation and from the progressive settling and development of the country would be mere guesswork, but it is probable that some years would elapse before the benefits would become commensurate with the outlay.

With these views, and from the information at hand, I am constrained to the opinion that Big Sunflower River alone is not worthy of improvement by locks and dams at the present time, and that such work is not a public necessity.

The last paragraph of the letter of instructions reads as follows:

> In the event of your reporting that the harbor or river is worthy of improvement by the General Government, you will please submit an estimate of the amount that will enable you to make a survey and report, including a project, with estimate of the cost of the improvement proposed.

In my annual reports for several years I have submitted large estimates for completing the improvement of Big Sunflower River under the approved project, both to accomplish more work in proportion to appropriations and to give more immediate and lasting benefits.

I consider Big Sunflower River worthy of improvement by the United States to a greater degree than has been authorized, and if the stream should be regarded, as it ought to be, part of a system of internal navigation composed of Coldwater, Tallahatchie, Yalobusha, Yazoo, Tchula Lake, and Big Sunflower rivers, I should feel no hesitation in recommending a thorough survey, not only of the last with a view to its improvement by locks and dams, but of the whole basin in connection with a like improvement of the main stem—the Yazoo—and the tributaries above. On this basis it might be possible to develop an internal navigation of over 600 miles in the Yazoo Basin at a very much less cost per mile than for Big Sunflower River alone.

Assistant Engineer Marshall's moderate estimate of $18,000 for a creditable survey of Big Sunflower River is concurred in by me, because the foundation of the system of levels has been laid. For the same reason a thorough survey of the streams of the Yazoo system could be made for a comparatively small amount, say $50,000, covering three seasons' work. Such a survey would pay for itself either in preventing an undertaking far beyond the demands of commerce or in enabling the constructing engineer to reduce the number of locks and dams very materially. The omission of one lock and dam would cover the charges for such a survey and of all local surveys and examinations if improvement by locks and dams should be approved by Congress.

I invite attention to report of Assistant Engineer Marshall and to the commercial statistics, which have been compiled from the best information obtainable. The report for the fiscal year 1895 gave the total freights of the Yazoo system as 220,591 tons and the estimated value $4,806,000.

Big Sunflower River alone is worthy of improvement by the United States to a much greater extent than first proposed, and the work is a public necessity. A survey of considerable magnitude would be required for a project for increasing the scope of improvement as an open river, and would cost $10,000.

Big Sunflower River alone is not worthy of improvement by locks and dams, and therefore no survey should be required.

Big Sunflower River as part of a system of internal navigation to be formed by locks and dams might be worthy of improvement in the same way, the extension depending upon the development of its valley, and eventually, probably, as high as Clarksdale.

The subject is worthy of serious study, and I am of the opinion that an exhaustive survey at a cost of not less than $50,000 should be undertaken of the streams of the Yazoo Basin in the same manner as now in progress under authority of Congress for Ouachita River and its principal tributaries, for the purpose of ascertaining the feasibility and cost of a system of locks and dams in that basin, and that such a survey is a public necessity.

Very respectfully, your obedient servant,

J. H. WILLARD,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE,
SOUTHWEST DIVISION,
Washington, D. C., April 28, 1896.

Respectfully forwarded to the Chief of Engineers, United States Army, concurring in the views of Major Willard respecting a comprehensive survey of the Yazoo system.

J. W. BARLOW,
Colonel, Corps of Engineers, Division Engineer.

REPORT OF MR. H. M. MARSHALL, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., March 12, 1896.

MAJOR: I have the honor to report on the examination of Big Sunflower River, Mississippi.

The river was examined in 1878 under direction of Major Benyaurd, and the following extract from Report of Chief of Engineers for 1879 contains the gist of the report made by that officer:

BIG SUNFLOWER RIVER.

"This river has its source at Mud Lake, in Coahoma County, Miss., near what is known as Horseshoe Bend on the Mississippi River. As a tributary of the Yazoo, it joins that stream about 55 miles above its mouth, flowing through the counties of Coahoma, Washington, and Issaquena, and forming part of the boundary between the latter and Yazoo County. During the high-water stages it is navigable for a distance of 280 miles, or as high up as the town of Clarksdale, in Coahoma County, which is known as the head of navigation. During the season of low water, however, the boats seldom ascend higher than Garvins Ferry, Coahoma County, a distance of 135 miles. It is not every year that they can reach this point. Some years the steamboat travel is entirely suspended for a short time; generally, however, we can depend upon uninterrupted low-water navigation for a period of ten months.

"The stream has a uniform low-water width of from 150 to 175 feet. The obstructions to navigation at low-water season consist of snags and sunken logs, and at all stages the leaning timber along the banks are serious obstructions. These obstructions could be readily removed and a channel way maintained of sufficient width and depth for the passage of such steamboats as are employed in carrying the commerce of the river. In many places the low-water channel, being filled with logs, is of no greater depth than 18 inches, while the confining snags on either side greatly reduce the width, leaving barely sufficient room for the safe passage of the small steamers that navigate the river. These obstructions are so general throughout the entire length of the stream, and are so constantly being brought in by the sliding banks, etc., that it would be useless to attempt any description of the points at which they are to be found. If any improvement looking to their removal should be attempted, the work should commence at the upper limit and work gradually down, taking out all obstructions that are met with.

"While these, as stated, abound throughout the entire river, there are two points especially mentioned between which they are found in great number and are a serious obstruction, viz, between the mouth of Silver Creek and Choctaw Bend (foot of Muscle Shoals). These two points are, respectively, 25 and 43 miles from the mouth of the Big Sunflower, thus covering a distance of 18 miles.

"While these obstructions are what might be termed accidental or temporary obstructions, there are two which are of a permanent character, viz, Oliphants Bar and Muscle Shoals.

"Oliphants Bar begins at the mouth of the river and extends a distance of 15 miles, though on the upper 3 miles is where the shoalest water is found, the depth throughout this section being about 18 inches, while the average on the portion below it is about 24 inches.

"Muscle Shoals are about 5 miles in length, the least depth of water over them being 17 inches, while the general average depth is 24 inches.

"The method of improvement suggested for these shoals is to build ordinary wing dams, and thus scour out a channel sufficiently deep for the passage of the small boats that navigate the river, from 3 feet to 40 inches being ample for the purpose."

Appropriations have been made by acts of Congress from time to time, and work has been prosecuted for the improvement of the river, a summary of which appears in Report of Chief of Engineers, U. S. A., 1894, pp. 1513, 1514.

The examination made by me on board U. S. S. *Thomas B. Florence,* February 24 to

29, extended from the mouth of the river to the Georgia Pacific Railroad crossing (Southern Railway) at Baird, in Sunflower County, a distance of 88 miles. By means of a drawing board mounted on a revolving pivot, and with the aid of a prismatic compass to get direction, and by time and speed of boat for distances, a sketch was made consisting of 9 sheets to scale about 1:10,000. This gives a fair idea of the relative widths of the river and the character of the country through which it flows.

Precise levels run in connection with improvement of Yazoo River in 1893, and those run in 1894 from Friars Point to Clarksdale, "as a base for checking levels to be run in surveying Big Sunflower River, with a view to its improvement as high as Clarksdale by locks and dams," afford the only information at hand concerning elevation of water surface and slope. In connection with the first levels, gauges were read through the high and low water of 1893 at Baird and at the mouth. * * *

From maps of United States Engineer Department survey of part of Yazoo River, and from county and township plats, 6 sheets have been compiled, on scale 1:50,000, showing the entire length of Big Sunflower, and also the Yazoo below Yazoo City.

From these sources it is learned that conditions have changed since the report of 1879.

In the first place, the distances then were overestimated—usually by one-third. From the mouth to Clarksdale is 180 instead of 280 miles. The channel width is not uniform, but ranges between 150 and 450 feet at ordinary boating stage between the mouth and the railroad bridge at Baird. Only in a few places does the timber on the banks constitute even an inconvenience to navigation, and now the banks are remarkably stable. Without doubt the latter change is due to the exclusion of the flood waters of the Mississippi by means of the levees. The measure of protection is illustrated on the sheet showing high and low water limits herewith.

Briefly, Big Sunflower runs nearly south along the median line through what is termed the Yazoo Delta. Its banks are generally high, being above overflow, and as stated, quite stable. Its bed is wide, and in that part known as the "Lake," about 23 miles in extent, it is deep. The slope and discharge are small, the latter at high water and at low water bearing the ratio 5 to 1. In addition to Oliphants and Muscle shoals, mentioned in the early report, there are nine short shoals below Baird. These are Callao, Hedrick, and Osceola, all affording a depth of 26 inches at low water and within a mile of each other; beginning 55 miles from the mouth, Hollywood, with 16 inches at the sixty-ninth mile; Shellridge, Woodburn, and Anderson, with 14, 24, and 16 inches at the seventy-sixth, seventy-seventh, and seventy-eighth mile; Sharp, with 28 inches at eighty-third mile, and Jenkins, with 16 inches at the eighty-sixth mile. That is, beginning at the mouth, in the first 33 miles the river is obstructed by shoals, the slope is concentrated, the banks wooded, and there are numerous outlets; in the next 23 miles the river is practically a wide deep lake, and above the lake there is a succession of pools and shallow places. The country tributary to the river is under cultivation to a considerable degree, and the further development is rapidly going on. This strip of territory, 104 miles long by 10 miles wide, is easily capable of yielding annually products to the value of $10,000,000.

Whether the river is susceptible of improvement by locks and dams at a cost commensurate with the benefit to commerce, present or prospective, will depend upon the quantity of water it discharges, the length of its pools, the distribution of its slope over the shoals, and the number and extent of low places along its banks to be artificially raised. These matters can only be ascertained by an accurate survey. This could be done in a fairly creditable manner for $18,000.

Assistant Engineer Ewens has collected all commercial statistics obtainable, and has embodied them in a report which is submitted herewith.

Very respectfully, your obedient servant,

H. M. MARSHALL,
Assistant Engineer.

Maj. J. H. WILLARD,
Corps of Engineers, U. S. A.

REPORT OF MR. JOHN EWENS, ASSISTANT ENGINEER, ON COMMERCIAL STATISTICS OF BIG SUNFLOWER RIVER.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., March 9, 1896.

MAJOR: In accordance with your orders, I have the honor to submit the following report on the commercial resources, present and prospective, of the Big Sunflower River, also the commercial statistics for the fiscal years 1888 to 1895, and for the past calendar year.

The usual difficulty in obtaining reliable reports from steamboats was encountered. The various owners, changes of port and clerks, and the clerical methods in vogue on the river render the information obtained from this source at times unreliable and misleading. To obtain a portion of the information below, the following plan

was followed: The usual information furnished by the steamboats was first obtained. A canvass was then made of all the plantation commission houses, grocers, hardware, etc., in order to obtain as close an estimate of the upstream freights as possible. A quite reliable estimate of the lumber and stave traffic was secured from the parties interested. In connection with this data the acreage of all lands contiguous to the Sunflower that were cultivated in the calendar year 1895 was obtained.

During the calendar year of 1895 the Big Sunflower River was reported navigable as follows:

January 1 to April 30, to Faisonia.
May 1 to June 1, to Woodburn.
June and July, to Campbellsville.
October 1 to December 31, to Baird.

The following stern-wheel steamers were reported as having navigated Big Sunflower River in the calendar year 1895 from Vicksburg and Yazoo City:

Name.	Tonnage.	Length.	Breadth.	Depth.	Draft.	
					Light.	Loaded.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Ft. In.*	*Ft. In.*
Maggie	50.73	85	19	3.5	1 5	3 6
Yazonia	62.84	95	19.8	3.5	1 6	3 6
Fifteen	75	103	18	3.5	1 8	3 0
Novelty	49.45	76.4	16.4	3	1 3	3 6
Atlanta	85.03	93	16.4	3.7	1 10	3 0
Mima	62.72	66	17	3.2	1 2	2 6
Crown Point	159.14	123	25	4.2	1 8	5 0
Birdie Bailey	109.74	111	22	3.5	1 10	4 0

The information obtainable regarding the number of trips made and the destination was so unreliable that it has been omitted. During extreme low water, when the bar at the mouth of the Yazoo River interferes, the river source of supplies is Yazoo City, Miss.

The following is the commerce reported for the fiscal years 1888-89 to 1894-95:

Articles.	1894-95.	1893-94.	1892-93.	1891-92.	1890-91.	1889-90.	1888-89.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Cotton	3,601	2,400	2,699	4,118	2,375	2,594	4,000
Cotton seed	5,760	5,700	5,250	5,450	3,500	3,975	6,000
Hides	24	12	19	12	.....	.....	1
Live stock	71	38	250	265	70	150	150
Saw logs	2,475	5,650	19,000	21,835	15,400	4,000	.....
Lumber	1,500	780	1,130	906	920	869	.....
Staves	8,105	9,405	9,840	4,430	3,219	5,250	490
Miscellaneous	375	2,050	1,088	2,549	2,027	.....	3,880
Total down freight	21,911	26,035	39,276	39,565	27,511	16,838	14,521
Return freight	2,623	4,285	4,023	7,489	4,473	5,322	9,680
Total	24,534	30,320	43,299	47,054	31,984	22,160	24,201
Estimated value	$956,000	$988,000	$893,000	$1,354,000	$945,000	$1,240,000	$1,858,000

The river commerce for the calendar year 1895, as far as can be ascertained from the sources of information referred to above, was as follows:

	Tons.
Cotton	3,560
Cotton seed	5,140
Hides	11
Live stock	60
Saw logs	1,500
Lumber	950
Staves	4,500
Miscellaneous	25
Total down	15,746
Return	1,700
Total	17,446
Estimated value	$796,400

I consider the above the most conservative estimate ever obtained for the Big Sunflower River. The marked shrinkage in the timber interests, saw logs, and staves was largely due to the continuous low-water stage of the river during the past two seasons. The amount of saw logs and staves cut and awaiting sufficient water to bring them out is estimated to be: Saw logs, 4,000,000 feet; staves, 500,000 pieces. As near as can be ascertained the Yazoo and Mississippi Valley and Georgia Pacific railways transported not less than four-fifths of the cotton and cotton seed produced in the Big Sunflower River Valley in the calendar year 1895. Although the former railway parallels the (right bank) Big Sunflower at distances of from 5 to 20 miles through the entire developed section of the river, the haul overland from the river to the railroad is expensive and at times hazardous, owing to the numerous little streams that have to be crossed and the undeveloped roads that have to be traversed. The acreage of cultivable lands directly tributary to the Big Sunflower is estimated to be about 600,000 acres; 25 per cent of these lands are already cleared and under cultivation. The majority of the planters are colored, who plant on a very limited scale. The remaining lands are covered with a fine growth of marketable timber and excellent grazing ranges of cane. Cypress, oak, ash, and gum are among the principal varieties of timber that seem to be almost inexhaustible. The lands of the Big Sunflower are regarded among the most fertile of the Delta, and produce readily hay, oats, and corn of a fine quality equally well as they produce cotton.

With uninterrupted navigation that would insure reasonable transportation facilities for the crops and supplies, it is probable that the lands already under cultivation would yield their maximum, while the forest of fine timber would find a paying market that would more than pay for preparing the lands thus cleared for cultivation.

Very respectfully, your obedient servant,

JOHN EWENS, *Assistant Engineer.*

Maj. J. H. WILLARD,
Corps of Engineers, U. S. A.

APPENDIX U.

IMPROVEMENT OF ARKANSAS RIVER AND OF CERTAIN RIVERS IN ARKANSAS AND MISSOURI.

REPORT OF CAPT. WILLIAM L. SIBERT, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Removing obstructions in Arkansas River, Arkansas and Kansas.
2. Arkansas River, Arkansas.
3. White River, Arkansas.
4. Black River, Arkansas and Missouri.
5. Current River, Arkansas and Missouri.
6. St. Francis River, Arkansas.
7. St. Francis River, Missouri.
8. Removing sunken vessels or craft obstructing or endangering navigation.

EXAMINATION.

9. Upper White River, Arkansas.

UNITED STATES ENGINEER OFFICE,
Mount Nebo, Ark., July 16, 1896.

GENERAL: I have the honor to forward herewith annual reports for the fiscal year 1896 of the following works of river and harbor improvement under my charge.

* * * * * * *

Very respectfully, your obedient servant,

WM. L. SIBERT,
Captain of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

U 1.

REMOVING OBSTRUCTIONS IN ARKANSAS RIVER, ARKANSAS AND KANSAS.

Object.—To remove (otherwise than by permanent works) obstructions to navigation.

Project.—Originally to raise and destroy snags, cut overhanging timber, remove bowlders and reefs by blasting and dredging, and to cut out sand bars by temporary wing dams. The survey of the river with a view to project for permanent improvement was included under this head.

Since appropriations for permanent improvement were made, blasting, dredging, and dams have been omitted from the project under this head, leaving the customary snagging operations only.

OPERATIONS OF PREVIOUS YEARS.

The first snagging operations were under the act of July 3, 1832. The work began about August, 1833, and February 18, 1834, is said to be the date of arrival of the first snag boat, *Archimedes*, at Little Rock. Of the work done prior to 1868 I am unable to give any information.

Abstract of work done, 1868 to 1895, inclusive.

Fiscal year.	Snags removed.	Trees cut.	Trees deadened.	Drift piles removed.	Between—
1868	134	.....	.....	.....	Mouth and Douglass Landing.
1869	50	1	.....	.....	(?)
1870	805	114	.....	.....	(?)
1871	1,169	5,925	.....	.....	Mouth and Illinois Bayou.
1872	542	257	.....	2	Mouth and Pine Bluff.
1873	110	44	.....	.....	Little Rock and Bentleys Bar.
1875	663	1,570	.....	23	Mouth and Fairdale.
1876	545	1,274	.....	5	Mouth and (?)
1877	193	234	.....	3	Mouth and Silver Lake.
1878	430	1,177	.....	11	Mouth and Little Rock.
1880	750	488	.....	19	Mouth and Trustee Bend.
1881	391	346	.....	23	Little Rock and Webbers Falls.
1882	976	3,460	.....	18	Mouth and Fort Smith.
1883	1,287	786	.....	8	Do.
1884	1,118	1,135	.....	8	Mouth and Fort Gibson.
1885	2,244	14,325	17	20	Mouth and near Pawnee Agency.
1886	109	14	.....	2	Mouth and Little Rock.
1887	1,385	143	.....	.....	Mouth and Fort Smith.
1890	552	231	.....	.....	Little Rock and Webbers Falls.
1891	300	2,000	13,000	.....	Little Rock and Mouth.
1892	787	544	.....	4	Mouth and Webbers Falls.
1893	862	670	.....	17	Pine Bluff and Dardanelle.
1894	387	1,346	.....	1	Little Rock and Hog Thief Bend.
1895	1,154	2,602	.....	19	Foot of cut-off and Ives Point.

During the time covered by the above abstract three snag boats have sunk while in service, the *Northwest* at Stanleys in fiscal year 1868, the *Thayer* at Bentleys Bar in fiscal year 1873, and the *Pioneer* at Hughes Bend in fiscal year 1893.

The records of the *Northwest* were lost when the boat sunk, hence her work is not included in that of 1868.

OPERATIONS OF THIS FISCAL YEAR.

The work under this appropriation this year was confined to reaches of river between foot of cut-off and Knotts Island, about 98 miles. The amount of work done under this head is shown in table below:

Month.	Snags removed.	Trees cut.	Drift piles broken up.	Between—
August	49	3	6	Douglass and South Bend.
September	54	141	4	Foot of cut-off and Samples.
October	277	175	21	Foot of cut-off and Frog Bend Landing.
November	346	19	14	Sandy Bayou and Cummings.
December	75	551	.....	Waddells and Knotts Island.
Total	801	889	45	

Other snagging operations are reported under the head "Improvement of Arkansas River, Arkansas."

PROGRESS OF WORK.

The Arkansas River has in the State of Arkansas about 370 miles of caving banks; most of the bars are built upon and many of the channel crossings are over rock heaps. The caving banks make continual contributions of snags; the wearing away of sand bars brings the older accumulations into the channel, and removing snags from the crossings allows the sand to wash and expose others.

All of these go to make snagging operations a continuous necessity.

The evidence of pilots and masters is that in the permanent reaches of the river the condition has been materially improved; in the shifting channels the relief is only temporary.

In the lower reaches of the Arkansas River its current is checked by the floods of the Mississippi; the snags and logs drifting toward that stream are deposited in the bed of the Arkansas in all conceivable shapes. In the absence of current the snags make no "breaks," consequently the dangers to navigation are greatly increased.

Snagging operations will be necessary as long as there is a caving timbered bank and a shifting channel; they should not be diminished for many years, and could profitably be increased.

APPROPRIATIONS AND EXPENDITURES.

Appropriations for operating snag boats on the Arkansas River have been made intermittently since 1832. Many of the early appropriations were combined with those of other rivers without stated distribution of funds. The estimate of expenditures is not given as absolute, but as a close approximation.

July 3, 1832 (less $38 carried to surplus fund)	$14,962.00
March 3, 1835	40,000.00
March 3, 1837	25,000.00
July 7, 1838 (less $1,115.66 carried to surplus fund)	38,884.34
From appropriations 1842–1844 (estimate)	80,000.00
August 30, 1852 (less $269.47 carried to surplus fund)	39,730.53
From appropriations 1866–1878 (disbursements reported by Colonel Suter)	344,831.59
March 3, 1879 (part)	30,000.00
June 14, 1880 (part)	35,000.00
March 3, 1881 (part)	25,000.00
August 2, 1882	35,000.00
July 5, 1884	36,000.00
August 5, 1886	19,875.00
August 11, 1888	25,000.00
September 19, 1890	20,000.00
From sale of *Reese*	20,000.00
July 13, 1892	20,000.00
From sale of *Missouri*	2,500.00
August 17, 1894	20,000.00
June 3, 1896	20,000.00
Total	891,783.46
Expended to June 30, 1895	864,675.53

Money statement.

July 1, 1895, balance unexpended	$7,107.93
Amount appropriated by act of June 3, 1896	20,000.00
	27,107.93
June 30, 1896, amount expended during fiscal year	6,421.87
July 1, 1896, balance unexpended	20,686.06
Amount (estimated) required for work annually	35,000.00
Amount that can be profitably expended for maintenance in fiscal year ending June 30, 1898	35,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

The commerce for the year ending May 31, 1896, is reported under the head "Improvement of Arkansas River, Arkansas."

U 2.

IMPROVEMENT OF ARKANSAS RIVER, ARKANSAS.

ORIGINAL CONDITION.

In addition to such obstructions as snags, the channel of this river was for nearly all of its length of a shifting character, and was obstructed by sand bars fed by caving banks. In the upper reaches there were some reefs of rock.

ORIGINALLY ADOPTED PROJECTS, AND ADDITIONS.

Prior to 1886, works upon this river were special improvements of detached reaches, generally with immediate reference to confining the channel to drawspans of bridges or the water fronts of towns, and to the improvement of some especially difficult crossing.

The act which became a law August 11, 1888, adopted the plan of improvement set forth in Appendix V 13, Annual Report Chief of Engineers for the fiscal year 1885, and in House Ex. Doc. No. 90, Forty-ninth Congress, first session (the former relating to the reach from Little Rock to the Mississippi River, via White River Cut-off, the latter to the reach of river from Fort Gibson to Wichita, Kans.), and extended it to the entire river from Wichita, Kans., to the mouth.

The estimate for the work was made in three parts: Annual Report Chief of Engineers, 1885, p. 1603, for improving Arkansas River from Little Rock to mouth, $2,538,544; Annual Report Chief of Engineers, 1888, p. 1386, for improvement between Fort Gibson and Little Rock, at a cost of $1,307,935, and Ex. Doc. No. 90, Forty-ninth Congress, first session, for improvement between Arkansas City, Kans., and Fort Gibson, $1,696,900. This act of August 11, 1888, adopts a project for improving Arkansas River from Wichita, Kans., to the mouth, mentioning distinctly the plans which include the estimates from Little Rock to the mouth and from Fort Gibson to Arkansas City, Kans., and by implication approves the estimate for improvement between Little Rock and Fort Gibson, making the approved estimate for improving Arkansas River from Wichita, Kans., to the mouth $5,543,379.

PRESENT APPROVED PROJECT.

To remove rock and gravel reefs by blasting and dredging, to contract the channel by dikes or dams, permeable or solid, of such construction as the local conditions require, and to hold the channel so obtained by revetment where necessary, from Wichita, Kans., to the mouth, the object being to secure a channel not less than 6 feet in depth from Little Rock to Mississippi River, via White River Cut-off, and not less than 2 feet in depth above Little Rock, Ark.

WORK DONE IN PREVIOUS YEARS.

ABOVE FORT SMITH, ARK.

At Ainsworth Crossing, near Holts Rock, on right bank, 18.5 miles above Fort Smith.—Two brush and stone dikes, 400 and 500 feet; total, 900 feet; built in fiscal years 1891, 1892. Repaired, 1895. Result, satisfactory. Object of work, to improve channel crossing.

Bruces Island, on left bank, 12 miles above Fort Smith.—One permeable dike, 350 feet long, in Cherokee Chute; built in fiscal year 1890. Never repaired. Object, to improve channel crossing at foot of island. Result, no improvement. The river cut a channel around the outer end of dam, and it is not now effective. The material in the Choctaw Chute was such that it could not wash.

Poteau Reach, on left bank, one-fourth to 3.5 miles above Fort Smith.—Six dikes, 320, 450, 600, 420, 300, and 1,150 feet (total, 3,240 feet); built permeable in fiscal years 1887 and 1890–91. Four of these, 320, 450, 600, and 420 (total, 1,790) feet, converted into solid stone-capped dikes in fiscal year 1893; two, 300 and 1,150 (total, 1,450) feet, still permeable and never repaired. Also one stone and brush dike 1,100 feet long, with training wall 1,000 feet (total, 2,100 feet), built in fiscal years 1878, 1879, to 8-foot stage. Present height about 4-foot stage. This last dike and training wall was built for the purpose of maintaining the channel on the Fort Smith side of river, which result was accomplished.

FROM LITTLE ROCK TO FORT SMITH, ARK.

At Fort Smith, near old wharf.—One brush and stone dike, 131 feet long, built in fiscal year 1885 to 12-foot stage. Present height about 2.5-foot stage. Object, to prevent caving along town front. Successful, so far as bank in question then was concerned. The town front now extends farther down the river, and some caving occurs along lower front.

Van Buren, on right bank, 178 miles above Little Rock.—Two solid stone-capped dikes, 900 and 600 feet; total, 1,500 feet. One dike, 900 feet, was built for a railway incline; the other, 600 feet, was built permeable in fiscal year 1889. Both converted into solid stone-capped dikes in fiscal years 1893–94. Object, to maintain channel through drawspans of St. Louis and San Francisco Railway Bridge and to remove sand bar from in front of Van Buren Wharf. Results, satisfactory as to channel through drawspans of bridge. The bar is still in front of the wharf and is increasing.

Moores Rocks, 168 miles above Little Rock.—One channel, 75 feet wide, 425 feet long, excavated to a depth of 2 feet at low water in fiscal years 1891–1893. Object, to obtain low-water channel depth of 2 feet over the main reef. Results, the 2-foot depth has been obtained, but the channel as excavated is difficult of approach for descending boats. Other rock reefs, above and below, do not at times have sufficient depth of water over them to permit boats to reach the cut through the main reef.

Dardanelle Reach, on left bank, 88 to 89 miles above Little Rock.—Three solid stone-capped dikes, 250, 200, and 140 feet; total, 590 feet. One, 250 feet, built of riprap stone on brush-mattress foundation in fiscal year 1894; one, 200 feet, was built permeable in fiscal year 1887, converted into stone-capped dike in fiscal years 1893, 1894; one, 140 feet, an old steamboat wharf, broken near shore, converted into stone dike in fiscal year 1894. Object, to improve channel over shoals and to remove bar from the town front of Dardanelle. Results, no improvement.

Head of Rectors Island, on right bank, 13.5 miles above Little Rock.—One solid dike, 500 feet long, and one dam, 700 feet long, across right-hand chute, both of riprap stone on brush-mattress foundation; built in fiscal year 1895. Object, to improve channel crossing. Results, satisfactory.

Crystal Hill, on left bank, 11.5 miles above Little Rock.—Two dikes 300 and 700 feet long (total 1,000) built of riprap stone on brush mattress foundation in fiscal years 1894 and 1895. Object, to improve Newtons Crossing. Results through two low-water seasons, satisfactory; though now the crossing is in bad shape. The upper dike (E) built just below Crystal Hill is practically gone. It was of riprap stone on brush mattress foundation; was built to 8-foot stage, with a top width of 8 feet at outer end and 12 feet at shore end. It was built in fiscal year 1894, when the river was at from 15 to 8 foot stage. The bank protection at shore end was not entirely completed. In fiscal year 1895 a settlement in the dike near the shore was repaired and a small mattress (40 by 60) was placed along the bank on the downstream side of the dike. The work seemed solid and in good condition up to December 20, 1895. A rise of near 20 feet occurred on this and the following day, after the subsidence of which only the outer end of the dike was found to be left, the rest of it having been washed away; even no trace of the foundation mattress was found.

Greathouse Bend, 6.5 miles above Little Rock.—One bank revetment 3,273 feet long; built in fiscal year 1895. Object, to prevent caving of right bank, and to prevent any great change in crossing at foot of bend. The revetment successfully held the bank, but the object of the work was not attained and additional works are in progress at this place.

Above Baring Cross Bridge, on right bank, 1.75 to 2.75 miles above Little Rock.—Five stone dikes, 240, 150, 320, 135, and 150 feet; total, 995 feet. Three of these, 240, 320, and 135 feet, built permeable in fiscal years 1888 and 1889, repaired in fiscal year 1892, and converted into stone capped dikes in fiscal year 1893. Two, 150 and 150 feet, built of stone on brush-mattress foundation in fiscal year 1893; all repaired in fiscal year 1894. Object, to remove sand bar from south drawspan of the St. Louis, Iron Mountain and Southern Railway Bridge. Results, satisfactory.

FROM LITTLE ROCK, ARK., TO MOUTH.

Reach below Little Rock Junction Railway Bridge, on left bank, no miles to 1 mile below Little Rock.—Four dikes, 400, 260, 250, and 400 feet, built as permeable dikes in fiscal years 1888 and 1889; converted into solid stone-capped dikes in fiscal year 1893. Each dike was built 400 feet long; the two shorter dikes were filled to the remaining lengths of the original structures. Object, to improve channel from Little Rock to Peach Orchard Bend. Results, formerly some improvement, but the crossing now is about as it was before works were built.

Meads Point, on right bank, 1.75 miles below Little Rock.—One permeable dike 200 feet long; built in fiscal year 1888. Never repaired. Object, to improve crossing. No permanent improvement.

Eagle Bend, on left bank, 20.5 miles below Little Rock.—Two permeable dikes, 600 and 394 feet; total, 994 feet; built in fiscal year 1888. Never repaired. Object, to improve channel crossing. Results, satisfactory. The lower dike and a small portion of the upper one are gone. All improvement here is stated as having been by the upper dike.

White Bluff, on left bank, 43 miles below Little Rock.—Two permeable dikes, 200 and 400 feet; total, 600 feet; built in fiscal year 1888. Never repaired. Object, to improve channel crossing. Results, at first satisfactory, but now the channel is about as it was before works were built. The upper dike is gone and the lower one is badly broken.

Pine Bluff Reach, on right bank, 65 to 67 miles below Little Rock.—Six

dikes, 1,520, 400, 200, 150, 150, and 150 feet; total, 2,570 feet. One dike 1,520 feet; built in fiscal year 1885; 400 feet of brush and sand boxes, and 1,120 feet permeable; repaired in fiscal year 1887; still permeable. Five dikes, 400, 200, 150, 150, and 150 feet, are now solid stone-capped dikes. Three of these, 400, 200, and 150 feet, built permeable in fiscal years 1885, 1890, 1891. One, 400 feet, repaired in fiscal year 1892, and converted into solid stone-capped dike in fiscal year 1893. Two, 200 and 150 feet, converted into brush and sand box dikes in fiscal year 1891 and into solid stone-capped dikes in fiscal years 1892 and 1893. The last two, 150 feet each, built of brush and sand boxes in fiscal year 1892, converted into solid stone-capped dikes in fiscal years 1893 and 1894. Two bank revetments, 7,395 feet long in all. One 2,115 feet, from dike 4 to dike 6, built in fiscal years 1893 and 1894. One beginning 600 feet below dike 6, extending downstream 5,280 feet, built in fiscal year 1892; repaired in fiscal year 1894. Object, to prevent caving along the town front. Results, satisfactory.

Fergus Place Reach, on right bank, 68 to 69 miles below Little Rock.—Four permeable dikes, 450, 800, 800, and 807 feet; total, 2,857 feet; built in fiscal year 1891; repaired in fiscal year 1892. One, 450 feet, repaired in fiscal years 1893 and 1894 by stone filling.

Rob Roy Reach, on right bank, 73.75 miles below Little Rock.—One permeable dike, 1,200 feet long, built in fiscal year 1891. Never repaired.

Fergus Place and Rob Roy reaches.—Object, general improvement of channel from Pine Bluff to Rob Roy Bridge. Results, no great improvement at any time. At present the series of dikes in Fergus Place Reach are not effective and the river has gone behind the upper dike entirely.

Red Fork, on right bank, 148.6 miles below Little Rock.—One bank revetment 4,800 feet long; built in fiscal year 1895. Object, to stop caving that endangered levee. Results, the revetment is in good condition, but the bank is wearing away some above the riprap near the lower end of the work.

GENERAL RESULTS.

The work done in previous years has been so scattered that only local improvements have resulted. There has been no increase of depth for a length of river sufficient for a steamboat trade. The amounts appropriated for the different reaches of river have been so small in comparison with the amount necessary to accomplish the work proposed in project in that reach that it has been impracticable to carry the work on systematically over a reach of river of sufficient length to be of any practicable benefit to navigation other than the maintaining of the channel through the drawspans of bridges.

The work done, however, if no great changes occur before money is available in sufficient quantity to carry on the work to advantage, will form a part of a complete system.

OPERATIONS OF THIS FISCAL YEAR.

Snagging operations.—By the snag boat *Wichita*, operating between Fort Smith and San Boise Bend, 50 snags were removed; also, between Olive Gin (18 miles below Little Rock) and Mill Creek (77 miles above Little Rock) 376 snags were removed. By the snag boat *Beauregard*, operating betweed Pine Bluff and Little Rock, 30 snags were removed.

Near Fort Smith.—Special project approved December 31, 1894.

Contemplated work: Restore Suter Dike and 500 feet of its training wall; erect at downstream end of the restored portion of training wall a cross dike extending 300 feet into the river and back to the high bar; also erect in the pocket in the right bank above the mouth of Poteau River two dikes, each 200 feet long, the dikes to be built of riprap stone on brush-mattress foundation; the Suter Dike and training wall to be restored by using riprap stone and quarry spawls. This work was in progress at the beginning of this year, and was completed November 15. High water in July and August greatly interfered with the progress of the work.

Fletchers Bend, between Palarm Creek and Cribbs.—Special project approved April 23, 1895. Contemplated work: Protect by revetment the right bank from foot of bar at Cribbs to head of bar opposite Palarm Creek. The plant to be used here was taken to the site of the work late in August, but the high stage of river prevented any other than preparatory work until late in September. On November 1 the river had fallen to so low a stage that it was impracticable to tow stone or brush, and work was temporarily suspended until the 10th of the month. On December 20 work was again suspended, this time on account of a 20-foot rise. On January 8 work was continued and carried forward until March 14, when it was suspended until low-water season. The plant remaining there was taken to Newton's Bend. The stone (delivered in place in work) was purchased under contract from Zeb Ward, jr., contract approved August 14, 1895. The brush, poles, and piles were purchased (delivered at the work) under contract from Zeb Ward, jr., contract approved August 14, 1895. Delivery of material was slow, and much of the stone was purchased in open market on bank and on barges, towed to the work with Government boats, and placed by labor hired by the Government. Much of the brush was towed from the brush field to the work by Government boats. These expenses were borne by the contractor. The mattress used was 60 feet wide, the bank was graded to the top to slope of 1 on 2, the riprap was carried up the slope to 15-foot stage by Dardanelle gauge. The work is not yet finished. Above 8-foot stage and below low water the work is complete. Between 8-foot stage and low water something like a mile of the bank is protected by brush mattress weighted with stone. This is to be riprapped when low-water season arrives. Total length of bank protected is 8,818 feet. Of the bank above the riprap, about 3,000 feet has been planted with Bermuda.

Head of Rectors Island.—Special project approved November 26, 1894. This work was practically completed at the close of last fiscal year. The small amount of stone required to complete the work was placed in October and November of this year.

Newtons and Greathouse Bends.—Special project approved February 1, 1896, modified and modification approved June 2, 1896. Contemplated work: At Newtons remove rack heap along right shore at head of Newtons Bend and revet the bank exposed to action of current by removal of rack heap. At Greathouse Bend extend revetment built last fiscal year and erect two dikes from right shore at the foot of the bend.

At Newtons work was begun February 26. The mattress was completed March 26. Bank grading and riprapping of bank not yet completed. Here the height of riprap is regulated by the height of the sand strata underlying the clay where this height is between 10 and 15 feet stage on Little Rock Signal Service gauge. When the sand is below the 10-foot stage, the riprap is to be laid to that stage. This

work was suspended in April, and condition is about as follows From stations 0 to 21, completed from 6-foot stage to average 12.5 stage. From stations 21 to 37–50, about 550 cubic yards of stone yet to be placed. Below low water the work is finished. Since suspension of work 420 cubic yards of stone have been delivered on the bank at the work. This and the amount remaining to complete the work is to be placed when low-water season arrives. Very little work was done on the removal of the rack heap, the stage of water being too high for this class of work.

At Greathouse Bend.—Work was begun March 28 and suspended June 11. The old revetment was extended upstream 1,000 feet and down stream 850 feet. Five hundred and seventy feet below the downstream extension a revetment 800 feet long was built. It is from this revetment that the two low-water dikes have been commenced. The upper dike (450 feet long) is located 150 feet below the head of it; the lower dike (500 feet long) is 500 feet below the upper one.

The riprap on bank at the revetments is carried to 15-foot stage, excepting at shore end of dikes and at lower end of the old revetments. At the shore end of dikes it is raised to 20-foot stage. At lower end of old revetment it was intended to raise the riprap for length of 200 feet to 20-foot stage, this length to extend 100 feet on old work and 100 feet on new work, but only 120 feet was so raised; the remaining 80 feet is raised to 18-foot stage. The riprap does not extend below 6-foot stage, the bank below this stage being protected by stone-weighted brush mattress.

The low-water dikes have not been completed. As they stand at close of the year they are simply two rows of stone piles of 6-foot stage height, having no width on top. These dikes and the revetments between low water and 6-foot stage are to be completed when low-water season arrives. The stone and brush used was purchased on 10-day circular, the brush delivered on barges at the brush fields, 10 to 20 miles below Little Rock; the stone was delivered on bank near mouth of Little Maumelle Creek.

Dike D above Baring Cross Bridge.—This was repair work. Caving below the dike threatened a cutting of the river around the shore end of the dike, to prevent which a mattress 60 feet wide and 250 feet long was sunk along the shore below the dike. The mattress is well weighted with stone, but the bank has not yet been riprapped.

Furgus Place Reach.—Special project approved June 4, 1895. Contemplated work: Remove what remains of Dike A°, and revet about 3,650 feet of caving bank, beginning 2,400 feet below lower end of Pine Bluff revetment. Brush mattress to be 120 feet wide, riprap to be carried to 15-foot stage. Actual construction not yet commenced. This spring, as opportunity afforded, 5,335 cubic yards of stone was towed from above Little Rock to Pine Bluff and stored there for use in the work.

Red Fork Revetment.—This work was not completed last fiscal year, and was so reported in last Annual Report. In July, 1895, 1,439 cubic yards of stone was towed from Big Maumelle, above Little Rock, to this place and distributed along the bank at points where needed. During the low water in latter part of November and first of December, 1895, this stone was placed, completing the work contemplated in the special project approved October 2, 1894.

Exhibits of the field expenditures on the above works are given below. The item "labor" always includes supervision, subsistence, etc.

Expense bill for work in vicinity of Fort Smith, Ark.

	Suter dike and training wall.			Cross dike on training wall.		
	Quantities.	Cost per unit.	Cost per item.	Quantities.	Cost per unit.	Cost per item.
Grading bank.						
Labor grading bank.....linear feet..	150	.....	$12.31	.....	.....	.....
Mattress.						
Mooring piles in place.....number..	.....	.....	.....	8	.....	$38.29
Brush delivered at work.....cords..	32.14	$1.75	56.24	138.72	$1.75	242.76
Poles .....number..	59	.09	5.31	252	.09	22.68
Wire.....pounds..	100	.02	200	450	.02	9.00
Labor weaving mattress.....squares..	67.02	.2588	17.23	310.16	.4127	127.99
Total cost of mattress.....do....	67.02	1.1605	77.78	310.16	1.4209	440.72
Stone.						
Stone delivered in work...cubic yards..	3,960.64	1.19	4,713.16	2,351.92	1.19	2,798.78
Spawls delivered in work .....do....	336.99	1.04	350.48	307.06	1.04	319.34
Inspection, weighing, etc.....do....	4,297.63	.1332	572.60	2,658.98	.1327	352.85
Total cost stone in place....do....	4,297.63	1.3117	5,636.24	2,658.98	1.3054	3,470.97
Miscellaneous.						
Property purchased	.....	.....	55.70	.....	.....	67.00
Repairs to plant.....	.....	.....	.....	.....	.....	33.86
Care of property during high water....	.....	.....	315.87	.....	.....	198.70
Total expenditures on work.....	.....	.....	6,100.90	.....	.....	4,211.25

	Dike E.			Dike F.		
	Quantities.	Cost per unit.	Cost per item.	Quantities.	Cost per unit.	Cost per item.
Grading bank.						
Labor grading bank.....linear feet..	150	.....	$37.19	150	.....	$33.24
Mattress.						
Mooring piles in place.....number..	.....	.....	.....	.....	.....	.....
Brush delivered at work.....cords..	102	$1.75	178.50	96.5	$1.75	168.87
Poles .....number..	151	.09	13.59	121	.09	10.89
Wire.....pounds..	250	.02	5.00	200	.02	4.00
Labor weaving mattress.....squares..	195	0.3890	75.86	198	.5325	105.44
Total cost of mattress.....do....	195	1.3995	272.95	198	1.4606	289.20
Stone.						
Stone delivered in work ..cubic yards..	1,044.29	1.19	1,242.71	959.22	1.19	1,141.47
Spawls delivered in work.....do....	40.98	1.04	42.62	35.96	1.04	37.40
Inspection, weighing, etc.....do....	1,085.27	0.1339	145.34	995.18	0.1349	133.31
Total cost stone in place....do....	1,085.27	1.3183	1,430.67	995.18	1.3185	1,312.18
Miscellaneous.						
Property purchased	.....	.....	33.50	.....	.....	32.90
Repairs to plant	.....	.....	16.92	.....	.....	16.75
Care of property during high water....	.....	.....	86.85	.....	.....	86.00
Total expenditures on work.....	.....	.....	1,878.08	.....	.....	1,770.27

	Suter dike and training wall.	Cross dike on training wall.	Dike E.	Dike F.
Brush used per square of mattress.....cords..	0.480	0.447	0.523	0.488
Poles used per square of mattress.....	.956	.809	.774	.611
Wire used per square of mattress.....pounds..	1.492	1.449	1.282	1.010
Cost of weaving one cord of brush.....	$0.535	$0.923	$0.743	$1.093

Exhibit of field expenses, Fletcher Bend revetment.

	Cost per unit.	Cost per item.	Total.
Grading bank.			
Labor grading 8,818 linear feet of bank	$0.3794		$3,351.02
Anchor piling.			
199 piles (20 feet long) delivered at work	1.20	$238.80	
Labor driving 195 piles	1.3096	255.38	
Fuel (estimated)	.05	9.75	
Total cost of anchor piles			503.93
Mattress.			
2,717.36 cords brush delivered at work	1.49	4,048.86	
5,513 poles delivered at work	.06	330 78	
8,621 pounds of wire		161.80	
Labor weaving 5,291 squares	.4541	2,402.95	
Total cost of 5,291 squares	1.3106		6,944.39
Stone.			
13,096.54 cubic yards stone delivered in place in work	.79	10,346.27	
Superintendence, inspection, etc	.03	393.26	
Total cost of stone	.82		10.739.53
Grass.			
Procuring Bermuda grass and planting same			234.62
Miscellaneous.			
Steamer expenses, transfer of plant to work		211.96	
Repairs to plant		461.44	
Property purchased		626.05	
Total miscellaneous			1,299.45
Expenditure on 8,818 linear feet of incomplete revetment	2.6166		23,072.94

Brush used per square of mattress	cords..	0.514
Poles used per square of mattress		1.042
Wire used per square of mattress	pounds..	1.629
Cost of weaving one cord of brush		$0.881

Exhibit of field expenditures, work at head of Rectors Island.

	Dike H.			Dam I.		
	Quantities.	Cost per unit.	Cost per item.	Quantities.	Cost per unit.	Cost per item.
Grading bank.						
Labor grading bank ..... linear feet..	150	.....	$32.03	.....	.....	$3.77
Mooring piles.						
Piles purchased, delivered at work..No..	10	$4.00	40.00	8	$1.90	15.20
Expense driving piles	10	3.249	32.49	8	2.605	20.84
Total cost of piles in place	.....	7.249	72.49	.....	4.505	36.04
Mattress.						
Brush purchased, delivered at work, cords	222.8	1.15	256.22	100	1.15	115.00
Do	.....	.....	.....	288.2	1.12	322.78
Do	.....	.....	.....	16	.....	17.70
Poles purchased, delivered at work.No..	580	.058	33.64	500	.058	29.00
Wire purchased, delivered at work.lbs..	1,000	.0175	17.50	1,750	.0175	31.18
Labor weaving mattress ..... squares..	503.44	.3451	173.77	801	.8030	643.20
Total cost of mattress..... do....	503.44	.9557	481.13	801	1.4433	1,158.86

Exhibit of field expenditures, work at head of Rectors Island—Continued.

	Dike H.			Dam I.		
	Quantities.	Cost per unit.	Cost per item.	Quantities.	Cost per unit.	Cost per item.
Stone.						
Stone purchased, delivered in place, cubic yards	3,088	$0.83	$2,563.04	4,086.3	$0.84	$3,432.49
Supervision, inspection, etc	.....	.1933	596.94	.....	.2069	845.57
Total cost of stone in place	3,088	1.0233	3,159.98	4,086.3	1.0469	4,278.06
Miscellaneous.						
Repair to plant, labor, and material	.....	.....	109.73	.....	.....	138.82
Property purchased	.....	.....	33.70	.....	.....	37.00
Care of property during high water	.....	.....	177.50	.....	.....	224.56
Total field expenses ..linear feet..	500	8.1331	4,066.56	.....	.....	5,877.11

	Dike H.	Dam I.
Brush used per square of mattress ..cords..	0.443	0.504
Poles used per square of mattress	1.152	.624
Wire used per square of mattress ..pounds..	1.986	2.184
Cost of weaving one cord of brush	$0.787	$1.566

Exhibit of field expenses, Newtons and Greathouse Bend revetments.

	Newtons Bend.			Greathouse Bend.		
	Quantities.	Rate per unit.	Cost per item.	Quantities.	Rate per unit.	Cost per item.
Grading bank.						
Labor grading bank ..linear feet..	3,750	$0.0814	$305.19	2,650	$0.1412	$374.20
Anchor piles.						
Piles, delivered at works ..number..	112	2.00	224.00	28	2.00	56.00
Labor, driving piles	112	.8862	99.25	28	1.4075	39.42
Fuel, driving piles	112	.0446	5.00	28	.0540	1.50
Total cost, piles in place	112	2.9308	328.25	28	3.4615	96.92
Mattress.						
Brush on barges ..cords..	1,180	1.17	1,380.60	789.55	1.17	923.77
Poles on barges ..number..	1,255	.05	62.75	1,003.	.05	50.15
Towage	.....	.....	531.10	.....	.....	240.81
Wire ..pounds..	6,878	.019	131.78	4,364	.019	82.82
Labor, weaving mattress ..squares..	2,250	.3684	828.96	1,590	.3347	532.13
Total cost of mattress ..do..	2,250	1.3045	2,935.19	1,590	1.1507	1,829.68
Stone.						
Stone on bank away from work ..cu. yds..	2,190.12	.32	700.84	3,819.10	.29	1,107.54
Do ..do..	574.44	.34	195.31	.....	.....	.....
Stone on bank at work ..do..	214.76	.34	73.02	.....	.....	.....
Labor, loading stone	2,764.56	.2656	734.27	3,819.10	.2656	1,014.35
Towage	2,764.56	.1231	340.35	3,819.10	.1297	495.33
Labor, placing stone	2,979.32	.1656	493.41	3,819.10	.1806	698.61
Total cost of stone in place	2,979.32	.8512	2,537.20	3,819.10	.8682	3,315.83
Miscellaneous.						
Repairs to plant, labor and material	.....	.....	122.08	.....	.....	91.18
Property purchased	.....	.....	279.09	.....	.....	239.20
Total expenditure on revetment, linear feet	3,750	1.7619	6,507.00	2,650	2.2442	5,947.01
Snag boat working on wrack heap	.....	.....	199.60	.....	.....	.....
			6,706.70			

Exhibit of field expenses, Newtons and Greathouse Bend revetments—Continued.

	Newtons Bend.	Greathouse Bend.
Brush used per square of mattress ....cords..	0.524	0.496
Poles used per square of mattress	.558	.631
Wire used per square of mattress ....pounds..	3.057	2.745
Cost of weaving 1 cord of brush	$0.702	$0.661
Cost of brush at work, per cord	$1.592	$1.475
Cost of poles at work, each	$0.074	$0.069

Exhibit of field expenditures on dikes at foot of Greathouse Bend.

	Upper dike.			Lower dike.		
	Quantities.	Cost per unit.	Cost per item.	Quantities.	Cost per unit.	Cost per item.
Mooring piles.						
Labor and stumpage, procuring piles	15	.....	$15.15	.....	.....	.....
Piles purchased, delivered at work	7	$2.00	14.00	13	$2.00	$26.00
Labor, driving piles	22	.9704	21.35	13	1.0161	13.21
Fuel (estimated)	.....	.0509	1.25	.....	.05	75
Total cost, piles in place	.....	2.3523	51.75	.....	3.0661	39.96
Mattress.						
Brush purchased ....cords..	117.89	1.17	137.93	132.62	1.17	155.16
Poles purchased ....number..	150	.05	7.50	169	.05	8.45
Wire purchased ....pounds..	652	.019	12.39	734	.019	13.95
Labor, weaving mattress....squares..	240	.3311	79.46	270	.3310	89.38
Towage of brush	.....	.....	35.96	.....	.....	40.45
Total cost of mattress...squares..	240	1.1385	273.24	270	1.1385	307.39
Stone.						
Stone purchased ....cubic yards..	868.77	.29	251.94	641.1	.29	185.92
Labor, loading stone	868.77	.2411	209.46	641.1	.2411	154.57
Towage	868.77	.1297	112.67	641.1	.1297	83.15
Labor, placing stone	868.77	.1277	100.94	641.1	.1277	81.87
Total cost of stone in place..cu. yds.	868.77	.7769	675.01	641.1	.7769	505.51
Miscellaneous.						
Property purchased	.....	.....	48.57	.....	.....	42.28
Total expenditure on dikes..lin. ft.	450	1.6079	723.58	500	1.0956	547.79

Exhibit of field expenditures, repairs to Dike D, above Baring Cross Bridge, at Little Rock, Ark.

Poles purchased, 75 at 5 cents	$3.75
Brush purchased, 88.34 cords at $1.17	103.36
Stone purchased, 135.36 cubic yards at 32 cents	43.28
Wire purchased, 450 pounds at 1.9 cents	8.55
Towage, brush and stone	26.50
Labor	112.50
Total	297.94

Exhibit of field expenditures procuring stone on bank at Pine Bluff, Ark., for Furgus Place Reach.

	Cost per unit.	Cost per item.
680.60 cubic yards stone on barges at Ives Point	$0.51995	$353.87
4,086.55 cubic yards stone on bank at Davidson Field	.39495	1,613.98
206.75 cubic yards stone on bank at Big Rock	.50	103.37
184.23 cubic yards stone on bank at Natural Steps	.35	64.48
Loading 4,654.07 cubic yards stone on barges	.2656	1,236.12
Towage of 5,334.67 cubic yards stone to Pine Bluff	.4103	2,208.90
Unloading 5,334.67 cubic yards stone onto slope of bank at Pine Bluff	.07074	377.40
Unclassified and miscellaneous expenses	.....	475.59
Total cost of 5,334.67 cubic yards stone on slope at Pine Bluff, Ark	1.2060	6,433.71

Exhibit of field expenditures, Red Fork revetment.

	Cost per unit.	Cost per item.	Total.
Grading bank.			
From annual report for 1895, 4,800 linear feet	$0.4205	.....	$2,016.25
Mattress.			
From annual report for 1895, 5,875 squares	1.5466	.....	9,086.54
Stone.			
From annual report, 1895, 8,491.98 cubic yards on barges at work	3.2083	$27,244.80	.....
Purchase of 1,438.76 cubic yards at work	1.50	2,158.14	.....
Inspection of loading and distribution of 1,438.76 cubic yards	.1343	193.20	.....
Total cost of 9,930.74 cubic yards at work	2.9802	.....	29,596.14
Ballasting mattress and bank.			
From annual report for 1895, 8,491.98 cubic yards	.1589	1,349.51	.....
Labor ballasting bank with 1,438.76 cubic yards	.1320	189.88	.....
Total cost ballasting mattress and bank with 9,930.74 cubic yards.	.1515	.....	1,539.39
Anchor piles.			
From annual report for 1895, 200 piles	2.9634	.....	592.68
Miscellaneous.			
From annual report for 1895	.....	.....	4,909.96
Total cost 4,800 linear feet of revetment	9.9460	.....	47,740.96

PLANT.

The plant formerly held under the head "Removing obstructions in Arkansas River, Arkansas and Kansas," having been by authority consolidated with that under the head "Improving Arkansas River," the repairs to all are reported regardless of appropriation under which the plant had been employed during this year.

Snag boat Wichita.—(Present hull launched December 29, 1888; docked December, 1895.) In June of this fiscal year the following repairs were begun on this boat: New deck and new deck beams in engine room and aft guards. New cylinder timbers. New wheel, entire; new splash bulkhead, new shoe blocks for shears, new canvas on skylight, and numerous small repairs. This will probably be about the last season this boat can be operated with the present hull.

Snag boat Beauregard.—(Launched July 20, 1893.) Roof recanvased. New head block in shears with new eyebolts. New deck and deck beams forward of capstans. Electric-light engine repaired with new packing rings, governor arms, and piston head. One new shaft for the doctor. One new crank, wrist pin, and new pinion for capstans. Boat painted throughout. Also necessary minor repairs to keep boat in commission.

Towboat Cleveland.—(Launched November 24, 1893.) The source of water supply was changed so that boiler feed pumps, instead of taking water directly from the river, now take it from a "well" under the pumps. One injector also placed as additional boiler supply. Boat painted throughout and necessary minor repairs made to keep boat in commission.

Barges (20 by 60 by 3).—Fifteen of these calked and repairs made to decks and rakes where required.

Pile Driver No. 2.—New braces for leads and four new sheaves. Two water-tight bulkheads placed at end of rakes.

Barges, Class A.—The construction of these barges (4) was in progress

at close of last fiscal year. This work began April 15, 1895; first barge (A195) launched May 13, 1895; second barge (A295) launched June 3, 1895; third barge (A395) launched June 19, 1895; fourth barge (A495) launched July 13, 1895. Boat yard cleaned; launching ways, blocking, etc., stored, and all work completed July 17, 1895. The barges are built of white oak throughout; are gunwale type with 10-foot rakes; 100 feet 4 inches long, 25 feet wide, and 5 feet deep from top of deck beams to bottom of floor timbers in the dead flat, measured at the side; 5-inch crown midship; no crown at head blocks; 12-inch sheer on sides; length of dead flat, 40 feet 4 inches. The bottom is planked athwartship, the deck planked fore and aft. Bottom and rakes are caulked with four threads of oakum, the first two threads are "horsed up," the last two "made in." All oakum seams are paid with red lead and oil. The decks are caulked with one thread of spun cotton and paid with resin pitch. Draft of barges, light, 14 inches. In launching barge A195 one bottom plank was broken, the break making a clean hole 12 inches wide and about 30 inches long. This was battened, and the barge pumped out by the steamer *U. K. Riggs*. A side dock was made and 4 feet of the broken plank was renewed.

Expense bill, building four barges, Class A.

MATERIAL.

Iron, assorted, 4,360 pounds	$90.65	
Spikes and nails, 4,700 pounds	123.75	
Mineral paint, 350 pounds	2.76	
Linseed oil, 50 gallons	31.00	
Carriage bolts, 1,506 pounds	43.42	
Oakum, 45 bales	132.00	
Lumber, white oak, 122,292 feet B. M	3,799.05	
Caulking cotton, 496 pounds	47.41	
Pitch, 4½ barrels	17.90	
Red lead, 200 pounds	10.75	
Miscellaneous supplies	13.05	
Cost of material		$4,311.74

LABOR.

Supervision	$373.00	
Caulkers	1,002.25	
Carpenters	1,344.56	
Common labor	384.31	
Watchmen	252.00	
Team service	5.90	
Cost of labor		3,362.02
Miscellaneous expenses		50.00
Total cost of 4 barges		7,723.76
Cost per barge		1,980.94

Dredge No. 1.—This dredge was purchased for Little Red River in March, 1889. After doing some work on that stream, it was brought to Little Rock in May, 1891, where it has remained since. Some three years and a half ago the engine and boiler was taken off. This year the dredge machine was taken off the boat and stored in the warehouse at Little Rock. The hull is rotten.

Dredge No. 2.—This dredge is now building at Fort Smith, Ark. The material for building the boat was purchased on circular. The first lumber was received March 26, construction work begun April 7, the hull launched May 30. The machinery was received June 2 and erection of it began June 13. There yet remains about three weeks' work to complete the dredge and have it ready for trial.

Miscellaneous.—Eleven barges (20 by 60 by 3) were condemned and sold. Barge 114 was sunk and raised. It went adrift in the rise in December and was caught at Brownes Bend in an old river channel, where it is at present and will have to remain until the river again reaches a high stage. One barge (21 by 90 by 4) was purchased.

CHANNEL.

The Arkansas River is a stream whose bed and banks are to a great extent composed of a sandy loam. This material is eroded very easily, and as a result the channel of the stream is continually changing, the concave banks wearing away and the opposite point bars building out.

From Little Rock to the mouth (173 miles) the river valley is entirely alluvial, and the entire bank is liable to cave if attacked by the water. Above Little Rock the conditions are the same, except at those places where the stream runs next to the hills that jut out into the valley. Even though the valley be very narrow, the character of the bottom land is the same.

From the data in the possession of this office, which is not very complete, the average amount of bank caved in per mile per year from Little Rock to the mouth is about 7.64 acres; from Little Rock above, about 1.99 acres.

Ordinarily, in low water there is approximately 3 feet of water on the shallowest crossings from the mouth to Silver Lake, a distance of about 40 miles. From there up to Webbers Falls, in Indian Territory, there is no great difference in depth, being about 16 inches on the shallowest crossings to 20 miles above Little Rock, and 12 to 14 inches from there on up. The increased depth in the lower 40 miles of the river is evidently due to a gentler slope and to the effect the backwater from the Mississippi has on this portion of the stream.

The checking of the current by this backwater causes immense deposits of material in that portion. When a concave bank wears away the opposite point bar builds up in two or three years to near the height of the original bank, thus keeping the river bed narrow, while above, where this condition exists, the high concave banks wear away and the bars opposite build up very slowly, and, as a consequence, when the river rises 2 or 3 feet, it spreads out until it is wider than in the lower part of the stream.

This condition, of course, requires more rainfall to produce a navigable depth, and causes, in a great many cases, a different channel in high and low water, leveling the bars and filling up the low-water channel to such an extent as to make it a difficult task for the low-water current to cut out its original channel.

The low-water channel, as a consequence, wanders between these high banks after different rises.

A quick rise of 20 or more feet in the river, followed by a rapid fall, leaves on many crossings not over 2½ or 3 feet with gauge readings at 10 or 12 feet. Last December there was one of these rises, the river changing from 3.5 on the gauge, December 20, to 17.2, December 21, and to 23.2 on December 27. The river began falling December 29, and on January 7 had fallen to 12.7 on the gauge.

The *Beauregard* on that day found only 24 inches on the crossing at Meades Point, where there had been 3 feet before the rise began.

The next day the channel had shifted a full quarter mile to the left, and 6 feet was found in it. In the latter part of June the river was slowly falling or practically stationary at 6 feet on Little Rock Gauge,

and at this stage 2 feet draft was all that could be taken from Swan Lake (27 miles below Pine Bluff) to Dardanelle.

COMMERCE.

There are no "long trade" packets on this river except by boats between Pine Bluff and Memphis, Tenn. Boats out of Fort Smith ply the river down to Roseville and up to Webbers Falls. The Little Rock boats go to Dardanelle and Roseville above and to Pine Bluff and Cummings below. The trips to Pine Bluff and below are made only when freights are assured them. The river trade from Pine Bluff to Memphis is handled by a packet line out of Memphis, Tenn., that endeavors to navigate the river the year round.

There is little change in the amount of commerce this year and the year previous. Whether there will be a revival of the trade or not, time alone can tell. Steamers to run this river with profit will have to be built with a comparatively large carrying capacity on small draft, and at present there is only one boat of this class on the river. It is in the Memphis and Pine Bluff trade. Should others be built to run in the Little Rock and Fort Smith trades some of the river freights that now go to the paralleling railroads may again go to the commercial centers by steamboat. The river has a marked influence on through railway freight rates to Pine Bluff, but has none on through freights to Little Rock. Between Little Rock and Dardanelle and from Fort Smith to points in the Indian Territory there is competition between the railways and steamboats.

APPROPRIATIONS.

Prior to 1886 appropriations were made for special work as follows:

June 14, 1880 (Pine Bluff)	$25,000
March 3, 1881 (Pine Bluff)	23,000
August 2, 1882 (Pine Bluff)	20,000
July 5, 1884 (Pine Bluff)	55,500
July 5, 1884 (Fort Smith)	5,000
Total expended on special works for which appropriated	128,500

The acts of August 5, 1886, and August 11, 1888, appropriated for the whole river, adopting the plans and approving the estimate ($5,543,379) for the permanent improvement of the river from Arkansas City, Kans., to the mouth. The appropriations for permanent improvement are as follows:

August 5, 1886		*$75,000.00
August 11, 1883		150,000.00
September 19, 1890		180,000.00
July 13, 1892		250,000.00
August 17, 1894		†250,000.00
June 3, 1896		100,000.00
Total		1,005,000.00
*Amount especially appropriated August 5, 1886, for work not included in project	$31,000.00	
†The use of $10,000 for removing obstructions authorized, not chargeable against approved project	10,000.00	
		41,000.00
Total appropriated for present project		964,000.00
Sale of United States quarter boats		5,000.00
Received on account of deposits made by Capt. William L. Sibert		352.91
Grand total		969,352.91
Total expended on project to June 30, 1895		698,797.65

Money statement.

July 1, 1895, balance unexpended		$164,867.15
Amount appropriated by act of June 3, 1896		100,000.00
Received on account of deposit made by Capt. Wm. L. Sibert		335.20
		265,202.35
Reserved in United States Treasury for freight charges	$304.71	
June 30, 1896, amount expended during fiscal year	95,091.93	
		95,396.64
July 1, 1896, balance unexpended		169,805.71
July 1, 1896, outstanding liabilities	$12,000.00	
July 1, 1896, amount covered by uncompleted contracts	2,500.00	
		14,500.00
July 1, 1896, balance available		155,305.71
Amount (estimated) required for completion of existing project		(*)
Amount that can be profitably expended in fiscal year ending June 30, 1898		500,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		

COMMERCIAL STATISTICS.

Pine Bluff, Ark., was head of low-water navigation from October 8, 1895, to November 12, 1895. No navigation was reported above Webbers Falls.

List of stern-wheel boats navigating Arkansas River, Arkansas, May 31, 1895, to June 1, 1896.

Name.	Tonnage.	Load draft. Steamer.	Load draft. Barges.	Between—	Round trips.	Passengers.
		Ft. In.	*Ft. In.*			
G. W. Mayo	124.06	3 0	2 6	Fort Smith and Webbers Falls	30	263
				Fort Smith and Red Land	23	
				Fort Smith and Shoal Creek	15	
Wm. Druhe. No. 2	179.18	3 6	3 0	No report	.....	.....
New Mary Morgan	137	3 0	2 6	Dardanelle and Little Rock	.....	.....
U. K. Riggs	119.62	3 0	2 6	Little Rock and Dardanelle	1	28
				Little Rock and Durham	1	
				Little Rock and Trundles	3	
				Little Rock and Caldwells	2	
				Little Rock and Stains	1	
				Little Rock and Delaware	2	
				Little Rock and Neeleys	2	
				Little Rock and Fourche Le Fevre River.	1	
				Little Rock and Cardens Bottom	1	
Fannie	80.09	4 6	2 6	Little Rock and Fourche Le Fevre River.	4	.....
				Little and Plum Bayou	4	.....
Rees Pritchard	196.20	3 6	.....	Little Rock and Cardens Bottom	3	8
				Little Rock and Dardanelle	1	4
				Little Rock and Wilsons	1	7
				Little Rock and Neeleys	1	8
				Little Rock and Mississippi River	1	*507
				Little Rock and Brodies	1	8
				Little Rock and Pine Bluff	1	4
City of Little Rock	219.08	4 6	3 0	Little Rock and Dardanelle	43	150
				Little Rock and Cummings	3	
				Little Rock and Pine Bluff	3	
				Little Rock and Plum Bayou	2	
				Little Rock and Cardens Bottom	1	
Eugene	508.85	5 0	.....	Memphis and Pine Bluff	24	420
J. N. Harbin	344.72	.....	.....	do	32	470
L. E. Patton	92	3 6	6 0	Memphis and Gondors Landing	4	.....

* Convicts.

The steamers *J. N. Harbin* and the *Fannie* came into this river this fiscal year. There are two boats now building at Little Rock to be used in the Little Rock trade.

*Indefinite.

Summary of commerce reported.

Articles.	1896.		1895.	1894.
	Estimated value.	Tons.	Tons.	Tons.
Cotton	$710,420	4,437	4,274	7,213
Cotton seed	76,608	9,576	9,146	38,310
Hides and skins	600	8	12	31
Live stock	9,640	241	175	287
Lumber	20,560	4,112	2,733	2,616
Staves and bolts	612	170	513	250
Provisions	572,800	3,580	2,033	4,647
Grain	15,790	1,579	1,992	3,185
Miscellaneous	955,050	9,943	12,220	5,784
Saw logs by steamer	5,760	2,880	6,000	.....
Saw logs by raft	32,380	16,190	11,400	1,240
Piling by raft	8,500	1,545	.....	.....
Total	2,408,720	54,261	50,498	63,563

Classification and distribution of commerce reported.

	By raft.		By steamboat.	
	Value.	Tons.	Value.	Tons.
Centering at Fort Smith	$7,830	1,490	$337,056	8,696
Centering at Little Rock	20,000	10,000	1,137,914	15,741
Pine Bluff and Lower River	18,800	6,695	887,120	11,639
Total	46,630	18,185	2,362,090	36,076

The Arkansas River is paralleled on the north side from Fort Gibson, Ind. T., to Swan Lake Landing, Arkansas, by the following railroads: Fort Gibson to Fort Smith, by the Kansas and Arkansas Valley; Fort Smith to Van Buren and Little Rock, by the Little Rock and Fort Smith Railway; Little Rock to Rob Roy, by the Little Rock Branch of the St. Louis Southwestern Railway; Rob Roy to Swan Lake Landing, by the Pine Bluff and Swan Lake Railway. At no point are these railroads over 12 miles from the river. On the south side of the river, from Little Rock to Douglas Landing, the Little Rock, Mississippi River and Texas Railway lies within 6 miles of the river. The river is crossed at Fort Smith by the Kansas and Arkansas Valley Railway, at Van Buren by the Texas Branch of the St. Louis and San Francisco Railway, at Little Rock by the St. Louis, Iron Mountain and Southern Railway and by the Little Rock Junction Railway, and at Rob Roy by the St. Louis Southwestern Railway.

U 3.

IMPROVEMENT OF WHITE RIVER, ARKANSAS.

OBJECT.

To secure and maintain a navigable channel of not less than 2 feet in depth at low water above Newport and not less 5 feet in depth at low water from Newport to the mouth.

PROJECT.

To remove snags and overhanging trees; to blast and dredge bowlders and rocks or gravel reefs; to contract the channel where necessary by dams and spur dikes.

WORK DONE IN PREVIOUS YEARS.

Snagging operations, building wing dams, closing chutes, and removing bowlders and rock reefs have been the operations on this stream in previous years. Reports of amount of rock and number of bowlders removed are not definite enough to enable one to give anything like an accurate report. The work done in construction of wing dams and the present condition of dams is given in one abstract, the snagging operations in another.

LIST OF DAMS BUILT AND PRESENT CONDITION.

[The miles refer to distance above mouth of river.]

Summers Shoal (*405.4 miles*).—From right bank, one stone and brush wing dam 450 feet long, built in fiscal year 1882; repaired in fiscal year 1884. Present condition: Is broken in three places near center; about 375 feet remain; average height, 1 foot above low water.

Red Bud Shoal (*401.8 miles*).—One stone dam across right-hand chute, 268 feet long, built in fiscal year 1882. One stone wing dam, 140 feet long, built from left bank in fiscal year 1884. Present condition: Dam on right bank down to low water; only traces left of wing dam on left bank.

Crooked Creek Shoal (*396.8 to 397.8 miles*).—From left bank four stone wing dams, 775, 685, 160, and 185 feet long, built in fiscal year 1882. Present condition: The 775-foot dam almost gone; barely shows at low water. The 675-foot dam is gone, excepting the training wall, which is 250 feet long and about 2.5 feet above low water. The other two barely show at an 0.5-foot stage.

Buffalo Shoals (*390.3 to 391.5 miles*).—From right bank four stone wing dams, 300, 200, 300, and 175 feet. From left bank three stone wing dams, 275, 100, and 150 feet, built in fiscal years 1879 and 1880. Repaired in fiscal years 1884, 1886, 1890, and 1894. Present condition: The 275-foot dam on left bank is gone; the others are in fair condition; the original lengths are retained; the average height is 3.5 feet above low water.

Martin Shoal (*380.3 miles*).—One stone and bush dam 186 feet long across chute on right, and one brush and gravel wing dam 100 feet long across low bar on right; both built in fiscal year 1890. Present condition: Both dams gone or covered with gravel.

The Rapides (*373.7 miles*).—Two stone dams 230 and 520 feet across chute on right, built in fiscal year 1880; one stone longitudinal wing dam 852 feet long from island on right, and two stone wing dams 60 feet each from left bank, built in fiscal year 1890. Present condition: The 240-foot dam is in good condition; of the 520-foot dam 120 feet remain in good condition, 180 feet are gone, and the balance is broken or covered with gravel. The 60-foot wing dams are gone; 760 feet of the 582-foot dam was rebuilt this year, the rest of it is gone.

Samms Island (*359.3 miles*).—One stone, gravel, and brush dam 150 feet long built across chute on left in fiscal year 1887. Present condition: Is about 125 feet long and barely shows at low water.

Samms Shoal (*357.8 miles*).—Two stone, gravel, and brush dams 313 and 175 feet long built across chutes on left in fiscal year 1881; rebuilt in fiscal year 1887. Present condition: Of the 313-foot dam 210 feet remain intact at a height of 0.5 foot above low water; the rest of dam

is broken; the 175-foot dam is gone and steamboat channel is now in the chute the dam was across.

White House Shoal (*355.4 miles*).—Two stone, gravel, and brush wing dams, one from right bank 850 feet long, one from left bank 710 feet long, built in fiscal year 1887. The 700-foot dam was extended 200 feet and 675 feet of the 850-foot dam was rebuilt in fiscal year 1890. Present condition: Both dams down to low water and nearly covered by gravel.

Piney Creek (*353.9 miles*).—Two stone wing dams, one 418 feet long from right bank, built in fiscal year 1887; one from left bank 310 feet long, built in fiscal year 1890. Present condition: One from right bank broken in several places and down to 0.5 foot above low water; one from left bank repaired this fiscal year.

Widemans Shoal (*352. 9 miles*).—From left bank one stone dam 120 feet and two stone, gravel, and brush dams 120 and 60 feet, all across chutes; built in fiscal year 1887. Present condition: The 120-foot stone dam is in good condition and is 3 feet above low water; the 120-foot stone, gravel, and brush dam is washed down to low water excepting 20 feet at shore end; the 60-foot dam is in good condition and is 2.5 feet above low water.

Fish Trap Shoal (*352.3 miles*).—One stone wing dam with training wall, 378 feet total length, built from left bank in fiscal year 1887; repaired in fiscal year 1890. Present condition: Rebuilt this fiscal year.

Soldier Rock (*351.3 miles*).—One stone wing dam 320 feet long was built from left bank in fiscal year 1887. Present condition: Gone.

Bone Island (*350.6 miles*).—One stone wing dam 68 feet long from left; built in fiscal year 1887. Present condition: Gone.

Jeffreys Shoal (*347.6 miles*).—One stone wing dam 290 feet long built from left bank in fiscal year 1887. Present condition: Only a few traces left.

Rock Rapides (*346.9 miles*).—One stone wing dam 173 feet long, built from left bank in fiscal year 1887. Present condition: Only 50 feet remain and that is only 0.5 foot above low water.

Perrins Shoal (*345.4 miles*).—Two stone wing dams 192 feet long each; the one from left bank built in fiscal year 1886 and raised in fiscal year 1887, and the one from right bank built in fiscal year 1887. Present condition: Dam on left bank is about 1 foot above low water; the one on right bank is gone.

Harris Shoal (*344.6 miles*).—One stone wing dam 140 feet long from right bank and one stone dam 350 feet long across chute from left bank; built in fiscal year 1887. Present condition: Wing dam on right bank gone. The dam across chute has one hole 40 feet wide washed out midway; also connection with the island is broken. About 200 feet of the dam remain at 3-foot stage.

Sylamore (*343.3 miles*).—One stone dam 550 feet long built across chute on left in fiscal year 1887. Present condition: Dam washed to about 0.5-foot stage and entirely covered with sand and gravel.

Round Bottom (*338.4 miles*).—Four stone wing dams, 56, 132, 300, and 136 feet, built from left bank in fiscal year 1887. Present condition: Barely a trace left of the 56-foot dam; nothing at all left of the 132-foot dam or the 136-foot dam. The 300-foot dam is down to 0.5-foot stage.

Wild Haws (*331.1 miles*).—Two gravel, stone, and brush wing dams, one from left bank 885 feet long, one from right bank 1,120 feet long, were built in fiscal year 1887. Present condition: There are a few traces of the dam on left bank. Of the one on right bank 500 feet remain at 2.5-foot stage. The other portion is down to low water.

McClellans Ferry (*320.1 miles*).—One gravel and brush dam 94 feet long, built across chute on left in 1887. Present condition: Badly damaged. About 50 feet remain at 2-foot stage.

Batesville Shoal (*318.6 miles*).—One brush and gravel dam 294 feet long, built in fiscal year 1883; repaired in fiscal year 1887. Present condition: Part gone and part covered by sand and gravel.

O'Neal Shoal (*316.5 miles*).—Two stone and brush dams 100 and 450 feet long, built across chutes on left in fiscal years 1885 and 1886. One wing dam on right 47 feet long, built in fiscal year 1887. Present condition: The 100-foot dam is intact; the 450-foot dam washed down to 1-foot stage and is broken in two places, and only about 200 feet remain. The 47-foot dam is gone.

Eherenhardts (*310.1 miles*).—Two gravel and brush wing dams, one from left bank 448 feet, one from right bank 512 feet; built in fiscal year 1885; repaired in fiscal year 1887. One stone wing dam 150 feet from island on right, built in fiscal year 1891. Present condition: Barely a trace left of 448-foot dam, the 512-foot dam is gone; the 150-foot dam was repaired and lengthened 250 feet this fiscal year.

Dark Corner or Wyatts Shoal (*309.7 miles*).—Two brush and gravel dams, one 462 feet long across chute on left, one 50 feet long across chute on right; built in fiscal years 1885 and 1886; repaired in fiscal years 1887 and 1890. Present condition: Only about 300 feet of the 462-foot dam remain, and they are down to near low water. The 50-foot dam is covered by gravel.

Cornwall Shoal (*305.8 miles*).—One stone wing dam and training wall from left bank, total length 230 feet, built in fiscal year 1892. Present condition: Wing dam rebuilt this fiscal year.

Greenbrier Shoal (*304.6 miles*).—One stone, gravel, and brush wing dam 520 feet long, built from right bank in fiscal year 1886; repaired in fiscal year 1887. Present condition: Is down to 0.6-foot stage.

Old Gillets Ford (*302.8 miles*).—One stone wing dam 900 feet long, built from right bank in fiscal years 1891 and 1892. This is locally known as "Batesville Dam." Present condition: 800 feet remain in good condition at 5 feet above low water, 100 feet at outer end have been taken down to low water.

Cato Shoals (*288.5 miles*).—One stone wing dam 285 feet long, built from right bank in fiscal year 1892. Present condition: Down to 0.6-foot stage.

Saffold Shoals (*283.4 miles*).—Two brush and gravel dams; total length, 1,250 feet; built in fiscal year 1882. One brush and stone wing dam, 175 feet long, built in fiscal year 1892, from right bank. Present condition: The 175-foot dam is covered by high bar. Those built in 1882 are either gone or covered by bar.

Haggletooth Shoals (*269.0 miles*).—Dams built across chutes in fiscal year 1882. One stone, gravel, and brush dam, 475 feet long, across chute on left, built in fiscal year 1892. Present condition: Of the dams built in 1882 there are no traces. The 475-foot dam is covered with gravel and sand.

Cleghorn Shoal (*267.8 miles*).—One brush and gravel dam, 687 feet long, built from left bank in fiscal year 1892. Present condition: Five hundred feet remains at 1-foot stage.

Rock Boat Shoal (*265.8 miles*).—One brush and gravel wing dam, 450 feet long, built from right bank in fiscal year 1892. Present condition: Average height, about 1.5 feet above low water.

Newport (*257.8 miles*).—One permeable dike, 145 feet long, built in

fiscal years 1890 and 1892. Present condition: All of wattling and 35 feet of dike gone.

Near Aberdeen (90.3 miles).—Two riprap stone and brush dikes, each 125 feet long, built from right bank in fiscal year 1894.

Near St. Charles (65.8 miles).—Two stone and brush dikes, 100 feet each, built in fiscal year 1894.

Head of Little Island (38.3 miles).—Two stone and brush dikes, 100 feet each, built in fiscal year 1894.

There was 630 feet of brush and gravel dams built at Arnolds Island and Maguire Shoals in the fiscal years 1881 and 1882. These are either gone or covered by sand and gravel.

Abstract of snagging operations, fiscal years 1871 to 1895, inclusive.

Fiscal year.	Snags removed.	Trees cut.	Trees deadened.	Drift removed.	Remarks.
1871	235	.....	.....	.....	Between mouth and Desarc.
1872	543	422	.....	3	Between mouth and Jacksonport.
1874	51	1,592	.....	1	Do.
1875	313	1,548	.....	5	Between Jacksonport and Buffalo Shoals.
1880	(?)	(?)	(?)	(?)	Between mouth and Jacksonport.
1881	270	298	.....	.....	Between mouth and Devall Bluff.
	56	105	.....	.....	Between Jacksonport and Buffalo Shoals.
1882	905	4,319	.....	2	Between mouth and Wild Cat Shoal.
1883	404	2,859	.....	6	Between mouth and Buffalo Shoals.
1884	93	95	.....	1	Between mouth and (?).
1885	484	1,137	426	.....	Between Jacksonport and Buffalo Shoals.
1886	.....	1,399	50	.....	At Buffalo Shoals.
1887	166	2,014	101	6	Between Newport and mouth.
1888	29	.....	.....	.....	Between Clarendon and Devall Bluff.
1889	131	27	.....	.....	Between Greenbriar and Indian Bay.
1890	28	8	.....	1	In Black Island Reach.
1891	12	.....	.....	1	Between Greenbriar and Maxwell's Gin.
1894	128	354	.....	.....	Between Batesville and head of Buffalo Shoals.
1895	323	1,636	.....	1	Between mouth and Haggletooth Shoal.

WORK DONE IN FISCAL YEAR 1896.

General statement.—Construction of Batesville Revetment was in progress at beginning of the year and was not completed until September, 15, 1895. Repair and rebuilding of wing dams was begun at Wild Haws Shoal July 6. From here the plant, consisting of store boat, quarter boat, pile driver, and six barges (20 by 60 by 3), was floated downstream and work done at the following places: Slip Up, Eherenhardts, Dark Corner, and Cornwall. Excepting the quarter boat *Albany*, the plant was then transferred to Oil House revetment work, which was begun on October 3, and completed November 12. The quarter boat *Albany* was taken to the Rapides in October when repair and rebuilding of wing dams was continued.

From here, floating downstream, work was done at McMullins, Fish Trap, and Harris shoals. Clearing channel of rock and bowlders was begun at Hayes Ferry, October 25. This work was carried downstream to Laffertys Creek, where a 30-foot rise abruptly ended the season's work on December 21. The snag boat *Sheldon* worked over the river between Reeds Bar and Wild Haws Shoal during July and August. After the plant was laid up at Batesville in December necessary repairs were made.

The pile-backed stone dams built consisted of a brush foundation mattress, through which was driven a single row of piles spaced 6 feet,

center to center. On the upstream side of this row of piles there was bolted level with the top of the dam a stringer of round timber faced to 8 inches on upstream side. The dams were then built up to desired height with riprap stone. The width of dams on top is 4 feet, upstream slope 1 on 2 and downstream slope 1 on 1. At all shoals where dams were repaired or rebuilt during the season borings were made in proposed channel to a depth of at least 4 feet below bottom of river to ascertain if solid rock would be reached by the scouring, but no rock was found.

DETAILED STATEMENT OF WORK ON WING DAMS.

At Wild Haws Shoal (*331.1 miles*).—From left bank, one pile-backed wing dam, 400 feet long; height, 5.5-foot stage by Batesville gauge; built July 6 to August 5, to replace the 886-foot dam of 1887. The brush used in mattress was cut and loaded onto barges near Batesville and towed to the work by the snag boat *Sheldon*. The length of team haul was 900 feet; cost, $0.2912 per cord. Cutting and loading onto wagons and onto barges cost $0.9081 per cord; towage cost $0.9593 per cord. The piling used was cut 2 miles from work at cost of $0.6773 and $0.5437 per pile. The 2-mile team haul cost $0.1722 per pile. The stringers were cut 1 mile from river to which they were hauled, then rafted 1 mile to the work. The stone was procured 1,500 feet from river to which it was hauled by teams at a cost of $0.2297 for hauling, then loaded on barges, floated 1,000 feet, and placed in work. Other items of expense are shown in the expense accounts given below. Rapid oscillations of the river and swift water made the work here the most difficult of the season.

At Slip Up or Johnsons Shoal (*314.1 miles*).—From Willow Point on right, one riprap stone longitudinal wing dam, 850 feet long; height, 4-foot stage by Batesville gauge; built August 6–28. The brush used was cut and loaded onto barges as the fleet was dropped down from Wild Haws. Two hundred and eighty-three cubic yards of the stone used was quarried near river bank at a labor cost of $0.367 and loaded onto barges at cost of $0.397 per cubic yard. Twelve hundred and ten cubic yards was procured 1,500 feet from river at cost of $0.3217 on wagons, hauled to river for $0.166, and loaded on barges for $0.194 per cubic yard. All stone used was, after loading on barges, floated 900 feet downstream and placed in work for $0.203 per cubic yard.

At Eherenhardts Shoal (*310.1 miles*).—Wing dam built in 1887 lengthened 250 feet by a pile-backed extension, height 4.5-foot stage by Batesville gauge, extension built August 28 to September 9. Piles and stringers were purchased delivered at the work. Stone was procured by hired labor at cost of $0.3578 on wagons, hauled 2,000 feet to work at cost of $0.2846, and placed in work at cost of $0.2602. Brush used was cut and loaded on barges as the fleet was dropped down the river from Wild Haws. On account of shoal water the pile backing was placed ahead of the mattress, which was woven from two barges, one above and one below the row of piles. The barges were held together by timber frames just high enough to clear the piles.

At Dark Corner (*309.7 miles*).—From left bank one pile-backed wing dam, 400 feet long, height 4.5-foot stage by Batesville gauge, built September 3–17, to replace the 462-foot wing dam of 1885–86. Piles and stringers were purchased delivered at the work, the brush cut and

loaded on barges as the fleet was dropped down the river from Wild Haws. Stone was procured by hired labor, hauled 1,600 feet at cost of $0.2833, loaded on barges at cost of $0.2158, and placed in work at cost of $0.2586 per cubic yard. As at Eherenhardts, pile backing was placed ahead of mattress.

At Cornwall Shoal (*305.8 miles*).—From left bank one pile-backed wing dam, 60 feet long, built on wing dam of 1892, height 3-foot stage by Batesville gauge, built September 18–20. Training wall, 90 feet long, built from outer end of wing dam September 28, 29, and November 13. This training wall is a single row of piles, 10 feet center to center, sheathed on outside with 2-inch plank.

At the Rapides (*373.7 miles*).—Seven hundred and sixty feet of the 852-foot dam built in fiscal year 1890, from island on right, rebuilt October 25 to November 5, to 2-foot stage by Calico Rock gauge. Five hundred and thirty-six feet was built 5 feet wide on top, the remainder 4 feet wide. The stone used was obtained 1,600 feet from the work and most of it was hauled directly to the work and placed without the use of barges.

At McMullans (*366 miles*).—One riprap stone dam across chute on right, length 100 feet, top width 4 feet, height 3-foot stage by Calico Rock gauge, built November 14–18. The brush used was procured directly at the work. The stone was hauled 1,000 feet at cost of $0.2543 per cubic yard and placed in the work, from wagons, at cost of $0.0545.

At Fish Trap (*352.3 miles*).—Wing dam of 1887, 328 feet long, train wall 50 feet long, top width 5 feet, height 1.5-foot stage by Calico Rock gauge, rebuilt November 18–28. A large portion of the stone used was obtained from bed of river near the work and the balance from the north bank of river where sandstone ledges were easily worked by bars and hammers. The stone was hauled directly to the work; average length of haul was 400 feet. Owing to exposed position of dam the stone was more carefully placed than at other work and the faces of the dam were paved.

Harris Shoal (*344.6 miles*).—From right bank on site of the 140-foot dam of 1887, one riprap stone wing dam, 200 feet long, top width 4 feet, height 3-foot stage by Calico Rock gauge, built December 3–10. The stone used was hauled in wagons to shore end of wing dam, trestles were built from shore along the center line of wing dam to outer end; along this line of trestle work the stone was wheeled and dumped directly into place in the work.

DETAILED STATEMENT OF CLEARING CHANNEL.

The work done under this head was that of removing loose rock, bowlders, solid rock, and snags from the channel and cutting some overhanging timber. Work was commenced at Hayes Ferry, October 25, at which time Calico Rock gauge read —0.3, a stage about as low if not the lowest known by present steamboat men. Up to November 25 the river remained at low stage, never getting above 0.3 on Calico Rock gauge. On November 26 the river began rising slowly and did not thereafter get below 0.9 on the gauge before referred to. The river varied between 0.9 and 1.9 until December 20 and 21, when a rise of over 30 feet caused the suspension of work for the season at Laffertys Creek. The quarter boat *Albany* was floated 20.4 miles to Batesville on this rise and laid up with the rest of White River fleet. The work

done under this heading and the localities are shown in the following statement:

Locality.	Miles from mouth.	Taken from channel.				Snags destroyed.	Trees cut.	Remarks.
		Bowlders.		Loose rock.	Solid rock.			
		No.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*			
Hayes Ferry	390.1	4	4					
Nellies Apron	388.3				4			
Cornells	375.6	4	3					
The Rapides	373.7	45	18.8		.3			
Hoosier Ford	372.6	7	6.5	12		1		
Hoosier Reach	372.1	4	4.8	3				
Point Livingstone	368.6	9	3	3.5	5			
Sneads Creek	366.5		1		5			
McMullens	366	13	25	42.5		4		
Jacks Creek	363.5	3	1.5	.5				
Devils Race Track	361.5	4	1.5	5				
Below Calico Rock	358.5	4	7.5	5.5	2			
Samms Chute	357.9			2				
McChristians	356.4	5	2	.3				
Piney Creek	353.9	4	1.5	23		1		(*)
Piney Reach	353.1	38	34			1		
Fish Trap Shoal	352.3	25	8.5	33				
Soldier Rock	351.3	13	6	10	3.5			
Natural Dam	350.6				10.3			
Mount Olive	348.2	1	2					
Rock Rapides	346.9	6	2	2				
Wootens	345.8	1	1					
Harris Shoal	344.6					4	151	
Sylamore	343.3	5	6			2		
Buck Island	339.9	9	13.5			10	4	
Round Bottom	338.4	17	7.5	15				
Porter Hodge	336.1	52	30	17.5				
Wild Haws	331.1					9	10	
Cajins Island	327.8					3		
Laffertys Creek	322	24	8	30		5		
Total		297	198.6	177.7	30.1	40	165	

* Fifteen cubic yards placed on old dam on left.

DETAILED STATEMENT OF REVETMENT WORK.

Batesville revetment (302.2 miles).—On right bank; length, 2, 300 feet; mattress, 40 feet wide; riprap carried to 20-foot stage by Batesville gauge. Construction was begun in fiscal year 1895, and in annual report for that year the weaving of mattress was reported as completed. A sudden rise in the river on July 7 took out a portion of the mattresses at lower end of work. This was repaired by weaving and sinking a mattress 40 feet wide and 540 feet long. The delivery of stone was slow and the work was not completed until September 15.

Oil House revetment (301.6 miles).—On left bank at town of Batesville; length, 1,830 feet; mattress, 40 feet wide; bank graded to slope of 1 on 2 to 15-foot stage by Batesville gauge, and riprap carried to same height. The bank at the revetment has an average height of 32 feet and was nearly perpendicular. Explosives were used to throw down the top of the bank. Bank grading was begun October 3 and completed November 4; mattress weaving began October 9 and finished November 9. The material was purchased on ten-day circular. The piling was delivered on the bank at the work, the brush on barges at the work, and the stone was delivered in place in the work. All material was delivered promptly and the entire work was completed November 12.

Below are given abstracts of the field expenditures on the various works completed this fiscal year. Excepting Oil House revetment all the work given in the abstracts lies above the town of Batesville. The item "labor" always includes supervision, subsistence, and watching.

Exhibit of field expenditures, clearing channel, White River, Arkansas, fiscal year 1896.

	Cost per unit.	Cost per item.	Total.
Bowlders taken out.			
Labor on 198.6 cubic yards	$1.8050	$358.47	
Explosives used	.....	165.87	
Total expenditure on bowlders	2.6408	.....	$524.34
Loose rock taken out.			
Labor on 177.7 cubic yards	2.3923	.....	425.11
Solid rock.			
Labor on 30.1 cubic yards	1.2366	37.22	
Explosives used	.....	55.68	
Total expenditure on solid rock	3.0864	.....	92.90
Snags taken out.			
Labor on 40 snags	2.1923	87.69	
Explosives	.....	75.04	
Total expenditure on snags	4.6803	.....	162.73
Trees cut.			
Labor cutting 165 trees	2.0648	.....	34.07
Miscellaneous.			
Property purchased	.....	185.70	
Transfer of plant	.....	96.66	
			282.36
Total expenditure clearing 68-mile channel	22.3750	.....	1,521.51

Exhibit of field expenditures, White River revetments, fiscal year 1896.

	Batesville revetment.				Oil House revetment.			
	Quantities.	Cost per unit.	Cost per item.	Total per item.	Quantities.	Cost per unit.	Cost per item.	Total per item.
Grading bank.								
Labor ..... linear feet..	2,350	$0.2151	$505.54		1,850	$0.3235	$598.55	
Explosives	.....	.....	.....		.....	.....	153.96	
Total cost of grading	.....	.2151	505.54	$505.54	.....	.4068	752.51	$752.51
Anchor piles.								
Piling purchased ..... number..	93	1.30	120.90		73	1.28	93.44	
Labor driving piles ..... do....	93	.9574	89.04		73	.5517	40.27	
Fuel driving piles ..... do....	93	.0484	4.50		73	.1506	11.00	
Total cost of piles in place ..... do....	93	2.3058	214.44	214.44	73	1.9823	144.71	144.71
Mattress, width 40 feet.								
Brush purchased, delivered at work ..... cords..	461	1.10	507.10		.....	.....	.....	
Do ..... do....	58.7	1.00	58.70		540.58	1.00	540.58	
Labor procuring brush ..... do....	99.25	1.5781	156.63		.....	.....	.....	
Poles purchased ..... number..	843	.05	42.15		657	.06	39.42	
Wire purchased ..... pounds..	2,510	.019	47.69		2,200	.019	41.80	
Labor weaving mattress ..... squares..	984.89	.3968	390.85		732	.4450	325.73	
Total cost of mattress ..... do....	984.89	1.2216	1,203.12	1,203.12	732	1.2944	947.53	947.53
Stone.								
Stone purchased, delivered in place ..... cubic yards..	3,742.52	.74	2,769.46		4,136.65	.76	3,143.85	
Inspection and weighing ..... do.....	3,742.52	.0774	289.70		4,136.65	.0193	79.89	
Total cost of stone in place ..... do.....	3,742.52	.8174	3,059.16	3,059.16	4,136.65	.7793	3,223.74	3,223,74
Miscellaneous.								
Transfer of plant from Newport	.....	.....	670.39		.....	.....	.....	
Property purchased	.....	.....	25.90		.....	.....	166.22	
Repairs to plant	.....	.....	134.04		.....	.....	14.16	
				830,31				180.38
Total cost of revetment ..... linear feet..	2,300	2.5269	.....	5,812.59	1,830	2.9229	.....	5,248.87
Brush used per square		0.6284 cord.				0.7385 cord.		
Poles used per square		1.08.				0.90.		
Wire used per square		2.548 pounds.				3.0055 pounds.		
Labor weaving 1 cord of brush		0.6315 dollar.				0.6026 dollar.		
Cost of hauling 1 cord of brush per 100-foot lead		0.0399 dollar.						

Exhibit of field expenditures, White River pile-backed wing dams, fiscal year 1896.

	Wild Haws wing dam.				Eherenhardts wing dam.				Dark Corner wing dam.			
	Quantities.	Cost per unit.	Cost per item.	Total per item.	Quantities.	Cost per unit.	Cost per item.	Total per item.	Quantities.	Cost per unit.	Cost per item.	Total per item.
Mooring piles.												
Labor procuring or purchase of piles	11	$0.8491	$9.34		6	$0.75	$4.50		7	$0.75	$5.25	
Labor driving piles	11	.6864	7.55		6	.7033	4.22		7	.7714	5.40	
Fuel	.....	.0483	.53		6	.....	.....		7	.....	.....	
Total cost of piles in place .....number..	11	1.5837	17.42	$17.42	6	1.4533	8.72	$8.72	7	1.5214	10.65	$10.65
Foundation mattress.												
Procuring brush .....cords..	92	2.0689	190.34		52.2	1.4692	76.69		87.0	1.1329	98.56	
Wire purchased .....pounds..	1,450	.0190	27.55		400.0	.0190	7.60		500.0	.0190	9.50	
Labor weaving mattress.....squares..	176	.2907	51.16		107.5	.6372	68.50		127.5	.6766	86.27	
Total cost of mattress.....do....	176	1.5287	269.05	269.05	107.5	1.4213	152.79	152.79	127.5	1.5242	194.33	194.33
Pile backing.												
Labor procuring or purchase of piles	73	.7159	52.26		44	.75	33.00		67	.75	50.25	
Labor driving piles.....number..	73	.6859	50.07		44	.7020	30.89		67	.7716	51.70	
Labor procuring or purchase of stringers	13	1.3377	17.39		10	1.00	10.00		12	1.25	15.00	
Labor placing stringers .....number..	13	2.04	26.52		10	1.986	19.86		12	3.3617	40.34	
Bolts purchased	.....	.....	17.55		.....	.....	12.00		.....	.....	18.42	
Total cost of pile backing.....linear feet..	400	.4097	163.79	163.79	250	.4230	105.75	105.75	400	.4393	175.71	175.71
Stone.												
Labor, procuring on wagons .....cubic yards..	1,179	.5497	648.15		900	.3578	322.04		734	.3152	231.33	
Explosives	.....	.....	32.60		.....	.....	.....		.....	.....	.....	
Labor, transporting and placing in work	1,179	.5537	652.83		900	.5448	490.33		734	.7576	556.10	
Building wagon road .....linear feet..	.....	.....	.....		800	.1207	96.56		400	.0532	21.28	
Total cost of stone in place....cubic yards..	1,179	1.1311	1,333.58	1,333.58	900	1.0099	908.93	908.93	734	1.1018	808.72	808.72

Exhibit of field expenditures, White River pile-backed wing dams, fiscal year 1896—Continued.

	Wild Haws wing dam.				Eherenhardts wing dam.				Dark Corner wing dam.			
	Quantities.	Cost per unit.	Cost per item.	Total per item.	Quantities.	Cost per unit.	Cost per item.	Total per item.	Quantities.	Cost per unit.	Cost per item.	Total per item.
Miscellaneous.												
Property purchased	.....	.....	$80.84		.....	.....	$103.56		.....	.....	$123.94	
Repairs to plant	.....	.....	56.07		.....	.....	16.73		.....	.....	17.66	
Transfer of plant	.....	.....	257.50		.....	.....	40.46		.....	.....	13.96	
Explosives, removing mooring piles	.....	.....	6.38		.....	.....	.....		.....	.....	.....	
				$400.79				$160.75				$155.56
Total cost of wing dam.....linear feet..	400	$5.4616	.....	2,184.63	250	$5.3477	.....	1,336.94	400	$3.3619	.....	1,344.97
Brush used per square of mattress	0.5228 cords.				0.4856 cord.				0.6823 cord.			
Wire used per square of mattress	8.2 pounds.				3.7210 pounds.				3.9215 pounds.			
Labor weaving 1 cord of brush	0.5611 dollar.				1.3123 dollars.				0.9916 dollar.			
Cost per 100 feet hauling 1 cubic yard of stone	0.0153 dollar.				0 0142 dollars.				0.0177 dollar.			
Stone procured on wagon per day, per man	3.4 cubic yards.				4.5 cubic yards.				4.76 cubic yards.			
Cost of served ration	0.39 dollar.				0.365 dollar.				0.3650 dollar.			

Exhibit of field expenditures, rebuilt and new wing dams, White River, Arkansas, fiscal year 1896.

	The Rapides.				Fish Trap Shoal.				Harris Shoal.			
	Quantities.	Cost per unit.	Cost per item.	Total.	Quantities.	Cost per unit.	Cost per item.	Total.	Quantities.	Cost per unit.	Cost per item.	Total.
Stone.												
Labor, procuring on wagons.....cubic yards..	615	$0.5102	$313.75		404	$0.5189	$209.62		427	$0.517	$219.74	
Hauling to work .....do....	615	.3398	209.00		404	.2501	101.48		427	.3683	157.28	
Placing in work.....do....	615	.1379	82.28		404	.2252	90.88		427	.2604	111.19	
Building wagon road	.....	.....	61.31		.....	.....	.....		.....	.....	13.13	
Building wheelbarrow trestle.....linear feet..	.....	.....	.....		.....	.....	.....		200	.0730	14.60	
Total cost of stone in place...cubic yards..	615	1.0835	666.34	$666.34	404	.9950	401.98	$401.98	427	1.2083	515.94	$515.94
Miscellaneous.												
Property purchased	.....	.....	124.98		.....	.....	73.87		.....	.....	97.15	
Transfer of plant	.....	.....	106.80		.....	.....	66.95		.....	.....	85.00	
				231.78				140.82				182.15
Total cost of dam.....linear feet..	760	1.1817	.....	898.12	378	1.4328	.....	542.80	200	3.4905	.....	698.09

	Slip Up or Johnsons Shoal.				McMullins Shoal.				Cornwall Shoal.		
	Quantities.	Cost per unit.	Cost per item.	Total.	Quantities.	Cost per unit.	Cost per item.	Total.	Material in place in work.	Cost per unit.	Total.
Mooring piles.									25 piles, 16 feet long	$3.8268	$95.67
Labor procuring piles....Number..	14	$0.4550	$6.37		.....	.....	.....		8 stringers, 22 feet.	2.9425	23.54
Labor driving piles....do....	14	.8100	11.34		.....	.....	.....		18 planks, 2 by 12 by 16	.9522	17.14
Fuel driving piles....do....	14	.0486	.68		.....	.....	.....		10 cords of brush.	2.4860	24.86
Total cost of piles in place....do....	14	1.3136	18.39	$18.39	.....	.....	.....		100 pounds of wire.	.0222	2.22
Mattress.									166 cubic yards stone	.9584	159.10
Labor procuring brush....cords..	192	1.1346	217.85		22.5	$0.3613	$8.13		Total cost.....	.....	322.53
Labor weaving mattress....squares..	332	.3799	126.11		28.8	.2865	8.25				
Wire purchased....pounds..	1,500	.0190	28.50		125	.0190	2.37				
Total cost of mattress....squares..	332	1.1219	372.46	372.46	28.8	.6518	18.75	$18.75			
Stone.											
Labor, procuring on wagons....cubic yards..	1,493	.3302	492.97		220	.1837	40.44				
Explosives.......	.....	.....	36.95		.....	.....	.....				
Transporting and placing....cubic yards..	1,493	.5692	849.78		220	.3088	67.94				
Total cost of stone in place....do....	1,493	.9241	1,379.70	1,379.70	220	.4926	108.38	108.38			
Miscellaneous.											
Property purchased.......	.....	.....	88.06		.....	.....	24.29				
Repairs to plant.......	.....	.....	33.17		.....	.....	20.69				
Transfers of plant.......	.....	.....	37.30		.....	.....	.....				
				158.53				44.98			
Total cost of dam....linear feet..	850	2.2695	.....	1,929.08	100	1.7211	.....	172.11			

Average of costs from all works fiscal year 1896.

Brush at works, per cord	$1.155
Mattress, per square	1.269
Weaving mattress, per square	.425
Piles in place	1.891
Stringers in place	4.666
Stone in place	.897

OPERATIONS OF SNAG BOAT SHELDON.

Pile driver, mattress boat, store barge, quarter boat *Albany*, three empty barges, and two barges of brush were towed from Batesville to Wild Haws early in July. Two barges of brush and two barges of stone were also towed from brush camp and from quarry to Batesville revetment. At the completion of the towing the snag boat continued snagging operations up to August 30. Three hundred and thirty-four snags were removed and 209 trees cut between Reed's Bar and Wild Haws Shoal, distance 77 miles. Maps showing location of certain works in fiscal year 1896 are inclosed.

PLANT.

Snag boat Sheldon.—Old cylinders taken out of engines and new ones (10 by 36 inches) put in. Minor repairs made to other machinery; hull and skiffs painted. Condition of steamer good, skiffs bad.

Snag boat Riverside (hand propelled).—The hull of this boat was sheathed on the sides. The boat is in bad condition and will probably be unserviceable at the end of the coming season.

Quarter boat Albany.—Roof calked, pitched, and painted; hull and cabin painted, minor repairs to deck and rakes. Condition poor.

Barges Nos. 2, 3, 4, 5, and 6.—Calked above water line and painted. New deck and rake plank where needed. Condition good.

Barge No. 1.—Repairs made during working season only such as were required to keep barge in condition for light work. Condition bad.

Pile driver.—Twelve planks put in deck, gunwales and rakes painted. Condition bad.

Skiffs (2) and Batteaux (4).—Minor repairs. Condition good.

RESULTS OF IMPROVEMENT WORK.

Since the close of operations in December the river has not reached a low stage and no surveys have been made to determine the effects of the wing dams, but the pilots running the portion of river worked report the Rapides improved; Fish Trap Shoal expected to be better than for several years past; Harris Shoal has cut out and 2 feet is expected at low water; Wild Haws doing nicely and at least 20 inches looked for in dead low water; Slip Up, effect of wing dam doubtful; Ehrenhardts and Dark Corner, 2 feet looked for in low water.

The rock obstructions removed were such as give the following channel depths and widths at stage corresponding with zero on Calico Rock gauge: Rapides to Sneades Creek (6 miles), depth 1.7 feet, width 35 feet; Sneades Creek to Lafferteys Creek (56 miles), depth 1.7 feet, width 80 feet, excepting at Porter Hodge Shoal, where 40 feet was the width obtained. There are gravel shoals between the Rapides and Lafferteys Creek that give less channel depth than that obtained over rock. Should these gravel shoals cut out enough to cause changes in the slopes of the river, the depths obtained over rock obstructions will be affected by the change.

The plan for improvement as given in Annual Report 1888, page 1410, in the reaches of river worked this year is to secure and maintain a navigable channel not less than 2 feet in depth at low water. Prior to 1888 considerable work had been done on this part of the river, and the plans set forth in the Annual Report for fiscal year 1888 are for a continuation of the work done in former years. The first work done

under the project of 1888 was in fiscal year 1890, when twelve shoals in the first 39 miles below Buffalo Shoal were worked on and a probable channel depth of 2 feet was reported. This report was accompanied with a statement which implied that if the work done that season did not procure the desired depth further operations under project of 1888 would be useless (Annual Report Chief of Engineers 1890, p. 1943). In fiscal year 1891 the work was extended down to near Batesville. Much relief to navigation was reported, but the 2-foot depth was not obtained and the plans and estimates of 1888 were reported as entirely inadequate so far as the river above Newport was concerned (Annual Report Chief of Engineers 1891, p. 2049). There were no further operations above Batesville until fiscal year 1894, when some rock obstructions were removed from three shoals.

The operations of this fiscal year have been of the nature of maintenance, the object being to prevent the channel from getting any worse, and as before stated 1.7 feet is the depth over rock at a stage 0.3 foot above the low water of 1895 by Calico Rock gauge, and this depth liable to be decreased by changes of slopes in the river. That this channel is of little benefit to low-water navigation the trip of the steamer *Dauntless* with quarter boat *Albany*, in tow from Batesville to The Rapides, is given as evidence. The steamer and quarter boat left Batesville October 12 and arrived at The Rapides (72 miles) on October 23. Through the pools the steamer would make 2½ to 3 miles per hour, but at the shoals the capstan on quarter boat did all the work. The table below shows daily progress and other particulars of the trip:

Date.	Batesville gauge.	Miles made.	Shoals lined over.	Why lined.	Time on shoal.	Remarks.
					h. m.	
October 12 ...	1.3	4.2	At Batesville Town, Gillets Ford, Gaymors Ferry.	Swift water...	.....	
October 13 ...	1.3	1	Cornwall	.....do	5 00	
October 14 ...	1.3	.5	Maxwells	Shoal water...	11 00	Boat lighted next morning.
October 15 ...	1.2	7.9	Dark Corner	Swift water...	1 00	Dam built four weeks before.
			Eherenhardts	.....do	30	Dam built five weeks before.
			Wolf Bayou	.....do	30	
			Slip Up	Shoal water...	2 00	Dam built six weeks before.
October 16 ...	1.1	6.5	.....do	.....do	3 00	
			Cackling Pullet	Swift water...	30	
			O'Neals	.....do	25	
			Batesville Shoal	.....do	1 30	
October 17 ...	1.1	9	Walls Ferry	.....do	45	
			Cajins Island	Shoal water...	3 00	
			Dry Creek	Swift water...	40	
October 18 ...	1	10	Wild Haws	Shoal water...	5 30	Dam built eight weeks before.
October 19 ...	1	9	Round Bottom	Swift water...	30	
			Buck Island	.....do	1 00	
			Sylamore	.....do	1 30	
			Harris Shoal	.....do	45	Touched bottom lightly.
			Mount Olive	.....do	45	
October 20 ...	1	9	Fish Trap	.....do	1 00	
			Whitehouse	.....do	1 00	
October 21 ...	1	8.5	Samms Chute	.....do	2 30	
			City Rock	.....do	2 00	
October 22 ...	1	2	McMullins	.....do	1 30	
			Sneades Creek	Shoal water...	9 00	
October 23 ...	1	4.5	.....do	.....do	50	
			Three Shoals	Swift water...	1 00	Arrived at Rapides at 12.45 p. m.

The steamer *Dauntless* is 104.5 feet long, 17.6 feet wide; gross tonnage, 97.38; net tonnage, 73.49; engines 6 inches diameter and 2 feet stroke, steam pressure 140 pounds. Her draft to Wild Haws was 16 inches and above that point was 13 inches. The quarter boat *Albany* is 76.5 feet long, 18.3 feet wide, and had draft of 14 inches to the Rapides.

The snag boat *Wichita* in 1894 had about the same difficulties in reaching Buffalo Shoals that the *Dauntless* had this year in reaching the Rapides.

It is said that no steamboat ever made a trip to the Rapides at a stage of river as low as that existing when the *Dauntless* went there in October. Accepting that as being a fact, the results of the work done in White River above Batesville since 1880 is this: During low water a steamboat of 16 inches draft can with difficulty go to Wild Haws and one of 14 inches draft can go to the Rapides, but the difficulties of so doing are such as will prevent any commercial navigation. Swift water appears to be about as great an obstruction as shoals. An extensive and expensive system of contraction works might remove the last-named obstruction, but the swift water would remain. A system of locks and dams will remove both obstructions.

The sum of $10,000 will be required annually for maintenance of this improvement.

CHANNEL.

Between Batesville and Buffalo Shoals (89 miles) the following shoals are reported as being the most troublesome: Cajin Creek, Sneades Creek, Rob Ford, Martins, Shipps Beach, and Nellies Apron. The most troublesome one is given first. The general condition of the channel between Batesville and Buffalo Shoal is shown above in the results of work done. From Batesville to Black River (37 miles) there is a slight increase in depth and not so much swift water. Below Black River (265 miles) 3½ to 4 feet is the ruling low-water depth.

COMMERCE.

The traffic of White River is divided into two distinct sections, which appear to be determined solely by business relations, for the stream is equally navigable between and below the sections. The traffic in the lower river centers at Devalls Bluff and Clarendon, and is carried on principally by boats that ply the river between Augusta and Indian Bay. The boats when full loaded draw from 3½ to 4½ feet and use, when freights require, barges of about same draft. They run regularly the year round.

The upper river commerce in the main centers at Batesville. This commerce is largely carried on by rafting, the estimated value of the rafted material being about two and one-half times that handled by steamboats, while in tons it is about fourteen times that handled by steamers. The steamboats that ply this part of the river are of 13 to 20 inches light draft and run whenever there is sufficient depth of water over the shoals.

Newport is another point at which White River commerce centers, but this commerce is nearly entirely made up from points on Black and Current rivers, and passes over only 6 miles of the White River.

There is some commerce by river between Batesville and Newport. This is apparently determined by railroad rates and to what market the material is en route. If for St. Louis, Mo., and Northern markets the

commerce leaves the river at Batesville and goes by rail, but if for Memphis, Tenn., and Eastern points the commerce from the upper river goes through to Newport, for from here are competing railways to the East.

Taking the river as a whole, and including the Black and Current River commerce that passes over 6 miles of the White River, the rafted tonnage is about two and one-half times that carried by steamboats, while the estimated value of steamboat freights is about twice that of the estimated value of the rafted material.

APPROPRIATIONS AND EXPENDITURES.

Appropriations for this river have been partly for limited reaches, partly for the whole river, and partly for this river in combination with others. Of the distribution of the expenditures under the latter appropriations I am unable to render any information.

The appropriations for this river separately, and for reaches of it, are as follows:

June 23, 1874	$50,000.00
August 14, 1876	10,000.00
March 3, 1879	10,000.00
June 14, 1880	20,000.00
June 14, 1880	5,000.00
March 3, 1881	8,000.00
August 2, 1882	6,000.00
August 2, 1882	4,000.00
July 5, 1884	35,000.00
August 5, 1886	18,000.00
August 11, 1888	25,000.00
September 19, 1890	30,000.00
July 13, 1894	75,000.00
August 17, 1894	$52,000.00
June 3, 1896	22,000.00
Total	370,000.00
Received on account of deposits made by Capt. Wm. L. Sibert	9.16
Sale of stone	212.50
Received on account of authorized corrected error	.56
Grand total	370,222.22
Expended to June 30, 1895	301,920.18

Money statement.

July 1, 1895, balance unexpended	$46,301.84
Amount appropriated by act of June 3, 1896	22,000.00
Received on account of deposit made by Capt. Wm. L. Sibert	.20
	68,302.04
June 30, 1896, amount expended during fiscal year	29,825.14
July 1, 1896, balance unexpended	38,476.90
July 1, 1896, outstanding liabilities	350.00
July 1, 1896, balance available	38,126.90

Amount (estimated) required for completion of existing project	14,815.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	14,815.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

No steamboat navigation was reported above Noes Ferry. Rafts were run from points as high up as the mouth of James Fork. Jacksonport was head of low-water navigation for boats of over 2 feet draft and Batesville was head of low-water navigation for boats of over 20 inches draft.

List of stern-wheel boats navigating White River, Arkansas, May 31, 1895, to June 1, 1896.

Name.	Tonnage.	Load, draft.		Between—	Round trips.	Passengers.
		Steamers.	Barges.			
		Ft. In.	*Ft. In.*			
Rex	144	3 6	3 6	Des Arc and Devalls Bluff	152	963
Ralph	97.99	4 6	.....	Devalls Bluff and Indian Bay	58	278
Emma	5.88	4 0	3 0	Devalls Bluff and Augusta	40	.....
				Devalls Bluff and Cache River	15	.....
				Batesville and Buffalo City	17	350
				Batesville and McBees Landing	12	
				Batesville and Oakland	4	
Dauntless	73.49	2 6	2 0	Batesville and Cajins	2	
				Batesville and Hell Creek	1	
				Batesville and Haynes	1	
				Batesville and Duluth	1	
				Newport and Batesville	10	50
				Batesville and Noes Ferry	2	155
J. A. Woodson	219.78	3 0	.....	Batesville and McBees Landing	10	
				Batesville and Buffalo City	18	
				Batesville and Wild Haws	1	
G. M. Sivley	98.94	5 0	5 0	Newport and (?)	3	50
				Newport and Black River	27	
A. R. Bragg	162.71	3 6	.....	Newport and Oil Trough	14	24
				Newport and Black River	71	(?)
L. E. Patton	92	3 6	6 0	New Orleans and Cache River	2	.....
Mary F. Carter	32.05	1 6	.....	Clarendon and (?)	(*)	(*)
T. E. Morrison	(?)	(?)	(?)	Batesville and (?)	(†)	356

* No report.

† Report not complete.

The steamer *G. M. Sivley* came into the river November, 1895. There are two boats now building at Batesville for the upper river trade.

Summary of commerce reported.

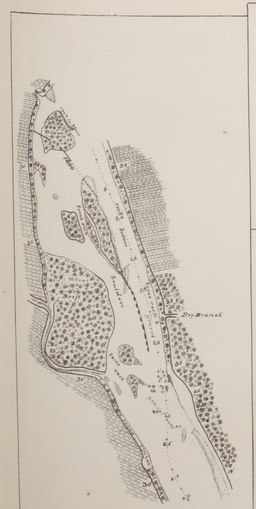
	1896.		1895 (tons).	1894 (tons).
	Estimated value.	Tons.		
Cotton	$750,580	4,693	4,928	3,968
Cotton seed	8,784	1,098	6,721	2,246
Hides and skins	2,775	37	90	20
Live stock	4,080	102	101	549
Lumber by steamer	9,060	1,812	4,098	5,461
Staves and bolts	19,267	5,624	5,203	2,772
Provisions	279,680	1,748	8,005	436
Grain	7,250	725	647	557
Miscellaneous freights	245,900	2,459	907	2,200
Spokes	.....	.....	437	.....
Square timber	.....	.....	2,750	.....
Saw logs by steamer	4,000	2,000	8,600	.....
Saw logs by raft	22,376	11,188	15,151	21,614
Railroad ties by raft	67,837	25,125	13,520	5,940
Cedar by raft	630,000	16,800	2,080	.....
Lumber by raft	1,064	266	521	.....
Staves by flatboat	4,338	1,205	.....	.....
Total	2,056,991	75,882	73,759	45,793

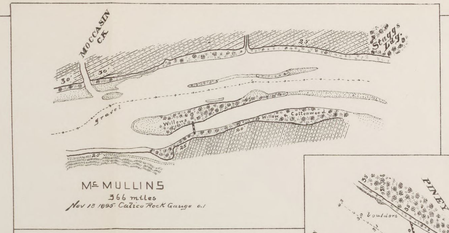
Classification and distribution of commerce reported.

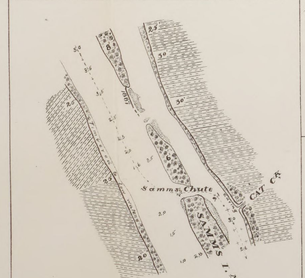
	By raft and flatboat.		By steamboat.	
	Value.	Tons.	Value.	Tons.
Centering at Batesville	$705,529	43,056	$322,867	3,015
Centering at Newport from White River	.....	.....	101,426	1,544
Centering at Newport from Black and Current rivers	8,046	4,023	435,365	9,740
Centering at Devalls Bluff and Clarendon*	17,000	7,536	464,398	5,318
Passing out of Lower White River to points on Mississippi River*	.....	.....	2,360	†650
Total	730,575	54,615	1,326,416	21,267

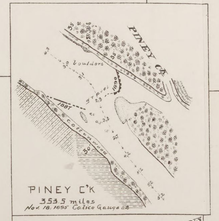
* Full reports not received.

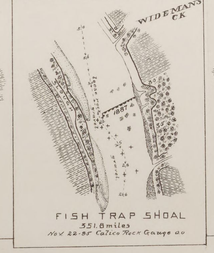
† For use in improvement works on Mississippi River about 20,000 tons of stone was towed from quarries on Little Red River. This passed over 182.5 miles of White River and is not included in above statements.

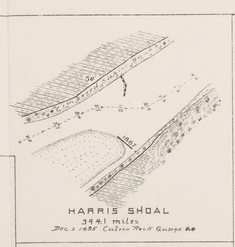

Dry Branch
THE RAPIDES
373.8 miles
Oct 28-1895 Calico Rock Gauge -0.5

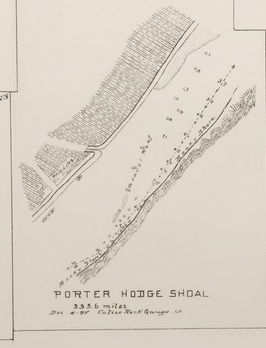

MOUCAND CK.
Sta 0 Cairo Ark 1895
McMULLINS
366 miles
Nov 13 1895 Calico Rock Gauge 0.1

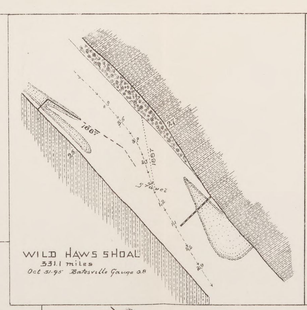

Samms Chute
CAT CK
SAMMS SHOALS
337.8 miles
Nov 16 1895 Calico Rock Gauge 0.1

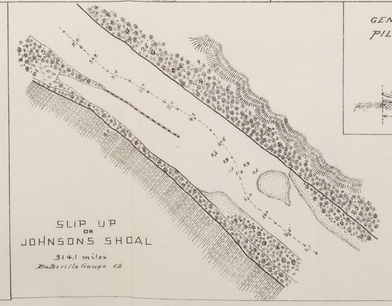

PINEY CK
PINEY Cr'k
353.5 miles
Nov 16 1895 Calico Gauge 0.8

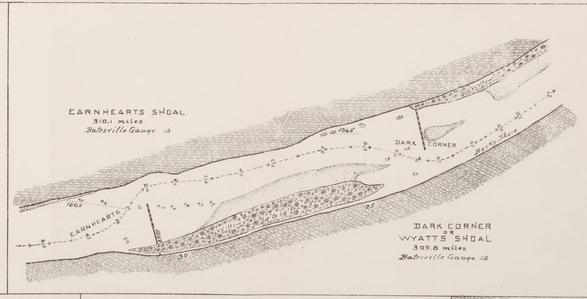

WIDEMANS CK
FISH TRAP SHOAL
351.0 miles
Nov 22-95 Calico Rock Gauge 0.0

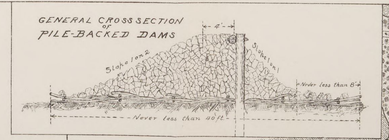

HARRIS SHOAL
344.1 miles
Dec 1 1895 Calico Rock Gauge 0.6


PORTER HODGE SHOAL
333.6 miles
Dec 4-95 Calico Rock Gauge 1.0


WILD HAWS SHOAL
331.1 miles
Oct 31-95 Batesville Gauge 3.0


SLIP UP
OR
JOHNSONS SHOAL
314.1 miles
Batesville Gauge 1.2


EARNHEARTS SHOAL
310.1 miles
Batesville Gauge 1.6
DARK CORNER
EARNHEARTS
DARK CORNER
WYATTS SHOAL
309.8 miles
Batesville Gauge 1.2


GENERAL CROSS SECTION
OF
PILE-BACKED DAMS
Never less than 30FT.

BATESVILLE
301.6 miles
OIL HOUSE REVETMENT
OLD GILLETS FORD
BATESVILLE REVETMENT
MAPS
SHOWING LOCATION
OF
SOME OF THE WORK DONE IN
FISCAL YEAR 1896
IN
WHITE RIVER ARK
Scale of feet
Dams built this fiscal year
Old Dams in good condition
Old Dams, practically gone
Old Dams broken
Dams repaired
Channel Cleared
CAPTAIN OF ENGRS U.S.A.

From Batesville to Jacksonport the White River is paralleled on the left bank by the Diaz and Batesville branch of the St. Louis, Iron Mountain and Southern Railway; from Jacksonport to Newport it is paralleled by White and Black River Valley Railway, also on the left bank. Three miles below Newport it is crossed by the main line of the St. Louis, Iron Mountain and Southern Railway. This railroad lies within 12 miles of the river (on the right bank) to Augusta. On the left bank, between Newport and Augusta, the White and Black River Valley Railway lies within an average distance of 9 miles.

Near Augusta the river is crossed by the Bald Knob and Memphis branch of the St. Louis, Iron Mountain and Southern Railway, and near Devalls Bluff by the Little Rock and Memphis Railway; at Clarendon, by the St. Louis Southwestern Railway.

COMMERCIAL STATISTICS OF CACHE RIVER, A TRIBUTARY TO WHITE RIVER.

The last two river and harbor bills have carried provision that some of the money appropriated for improvement of White River may be expended on Cache River. The Cache River reports having been dropped, the commercial statistics of that stream are here embodied as part of White River report.

It is not believed that full report of rafted commerce has been received. In years past much timber has been rafted from this stream to New Orleans. It is probable that the same occurred this year, but no report has been received of any. There is some improvement in the class of commerce handled. Formerly rafted saw logs was about all the material reported. This year rough staves and stave bolts make up the greater amount of the commerce. Two steamboats report having been in the river, being the first in a number of years, and there is some talk of one to be built to navigate this stream above the Little Rock and Memphis Railway Bridge.

The steamer *Emma* with barges (12 by 75 by 3) reports making fifteen trips to stave camps about 30 miles above the Little Rock and Memphis Railway Bridge. The *L. E. Patton* with barges (26 by 176 by 7) reports making two trips to the bridge above mentioned. The steamer could not pass the bridge, and the staves, which were made at points about 30 miles above the bridge, were loaded onto barges and floated to the *Patton*.

Summary of commerce reported for Cache River.

	1896.		1895 (tons).
	Estimated value.	Tons.	
Saw logs by raft	$15,340	7,670	12,150
Railway ties by raft	.....	.....	417
Lumber by flatboat	220	44	.....
Saw logs by flatboat	.....	.....	36
Staves by steamer	3,723	1,034	.....
Stave bolts by flatboat	43,200	12,000	.....
Total	62,483	20,748	12,603

Of the commerce reported 1,034 tons of staves and 1,000 tons of saw logs passed out of the river for points on White River or on the Mississippi.

The Cache River is crossed at Riverside by the White and Black River Valley Railway; at 4 miles below Riverside by the Bald Knob and Memphis branch of the St. Louis, Iron Mountain and Southern Railway, and at 7 miles above James Ferry by the Gregory branch of the White and Black River Valley Railway. Between Riverside and Yorks Landing it is paralleled on the east by the White and Black River Valley Railway, the greatest distance apart being about 6 miles.

U 4.

IMPROVEMENT OF BLACK RIVER, ARKANSAS AND MISSOURI.

The first independent appropriation for this river was made by act of Congress approved June 14, 1880, and the report for that fiscal year implies that the appropriation was based upon report of an examination

provided for by act of Congress approved March 3, 1879. (Annual Report Chief of Engineers, 1880, Part II, p. 1326.)

Original condition.—The general obstructions to navigation were shoals, snags, logs, and leaning timber. The first 31 miles below Poplar Bluff was a mass of snags and leaning trees.

Object of improvement.—To improve navigation between Poplar Bluff, Mo., and the mouth.

Project.—Procure and operate a light-draft snag boat, close chutes by dams, and improve shoals by wing dams. In late years no dams have been erected.

Work done in previous years.—In 1859 Butler County, Mo., caused some work to be done on the first 12 miles below Poplar Bluff. This consisted in cutting trees and removing drifts. Work done by the United States under the headings, "Improvement of Black River, Arkansas," "Improvement of Black River, Arkansas and Missouri," and "Improvement of Black River, Missouri," is given in the abstract below:

Abstract of work done in previous years.

Fiscal year.	Snags removed.	Trees cut.	Trees deadened.	Drifts removed.	Linear feet wing dams built.	Remarks.
1881	556	586	.....	.....	.....	Between mouth and Corning Bridge (199 miles).
					850	Devils Race Path.
					500	Eagle Nest (2 dams, 150 and 350 feet).
1882	388	1,100	157	.....	.....	Between mouth and Current River (146 miles).
	583	2,000	.....	.....	.....	Between Poplar Bluff and into chute; dams built across heads of Dan River.
1883	1,175	5,386	.....	.....	.....	Between Poplar Bluff and mouth of Dan River.
1884	1,429	2,480	1,393	.....	.....	Between mouth of Dan River and Schaffers Eddy. (?)
1885	120	9,291	3,607	1	.....	Between mouth and Prices Cut-off; snag boat Sheldon built.
1887	540	10,130	16,004	4	.....	Between mouth and Black Rock (108 miles).
1889	293	1,874	17,490	12	.....	Between Black Rock and Current River and between Poplar Bluff and State line; dam at head of Dan River rebuilt.
1890	140	215	2,444	15	.....	Between Poplar Bluff and mouth of Current River (123 miles); dam at head of Dan River repaired.
1891	406	10,450	.....	23	.....	Between Poplar Bluff and State line (42 miles).
1892	1,755	24,622	.....	166	.....	Between State line and Current River (81 miles).
	391	8,474	.....	.....	.....	Between State line and Poplar Bluff.
1893	818	9,315	.....	24	.....	Between Poplar Bluff and Hoover Place.
1894	181	6	.....	.....	.....	Between Lockhardt's Landing and Current River.

Present condition of dams.—The dam across Dan River is gone. The one at Devils Race Path is about 10 inches above low water, and has one break in it. The 150-foot dam at Eagle Nest is nearly covered by sand bar; the 350-foot dam is about 6 inches below low water.

Operations during the fiscal year 1896.—From September 1, 1895, to December 20, 1895, by operations of the snag boat *Sheldon* between the mouth and Current River (146 miles), 973 snags were removed and 760

trees cut. After the close of snagging operations the *Sheldon* was run to Batesville on White River and laid up with the White River fleet.

Channel.—This river is navigable for a distance of about 269 miles; much rafting is done throughout the entire length; sunken saw logs and fallen timber accumulate rapidly, more especially in the upper reaches, and it is my opinion that snagging operations could with profit be increased. Below the mouth of Current River, the Black River, with the exception of a few snags and some overhanging timber, is in good condition, and during the low water of November and December, 1895, 4½ feet was reported as the available depth.

Commerce.—The commerce of the portion of Black River above the mouth of Current River is that arising solely from lumber and stave industries. Saw logs, rough lumber, and staves are rafted or towed in barges to railroad points, and provisions and miscellaneous freights are taken thence to the timber and stave camps.

Below the mouth of Current River, plantation products and supplies, together with timber products, make up the commerce.

APPROPRIATIONS AND EXPENDITURES.

Appropriations have been made for this river separately and in combination with other rivers. Of the distribution of the expenditures under the latter appropriations I have no information to present.

The appropriations for this river, separately, are as follows:

June 14, 1880	$15,000.00
March 3, 1881	6,000.00
August 2, 1882	10,000.00
July 5, 1884	20,000.00
August 5, 1886	5,000.00
August 11, 1888	5,000.00
September 19, 1890	5,000.00
July 13, 1892	5,000.00
August 17, 1894	9,500.00
June 3, 1896	8,000.00
Total	88,500.00
Sale of United States snag boat	4,500.00
Received on account of deposit made by Capt. Wm. L. Sibert	18.88
Grand total	93,018.88
Expended to June 30, 1895	75,899.18

Money statement.

July 1, 1895, balance unexpended	$9,119.70
Amount appropriated by act of June 3, 1896	8,000.00
	17,119.70
June 30, 1896, amount expended during fiscal year	4,787.80
July 1, 1896, balance unexpended	12,331.90
July 1, 1896, outstanding liabilities	100.00
July 1, 1896, balance available	12,231.90
Amount (estimated) required for work annually	8,000.00
Amount that can be profitably expended for maintenance in fiscal year ending June 30, 1898	8,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

Steamboats report navigating Upper Black River seven months during the year. Below the mouth of Current River, the Black River is navigable all the year.

List of stern wheel boats engaged in navigating Black River, Arkansas and Missouri, May 31, 1895, to June 1, 1896.

Name.	Tonnage.	Loaded draft.		Between—	Round trips.	Passengers.
		Steamer.	Barges.			
		Ft. In.	*Ft. In.*			
G. M. Sivley	98.94	5 0	5 0	Mouth of Current River and Newport.	27	50
Portia	49.66	3 0	3 0	Black Rock and Pocahontas	104	806
				Black Rock and Martins	104	
Krata		1 6	3 0	Black Rock and Pocahontas	78	342
				Black Rock and Martins	78	
Ada (screw)	4	3 9	4 0	No report. Sunk.		
Moark	27.33	2 2	4 0	Poplar Bluff and Carola	111	550
A. R. Bragg	162.71	3 6		Newport and mouth of Current River.	53	1,872
				Newport and Elgin	18	
				Black Rock and Martins	20	
Black Diamond	18.40	3 0	3 6	Black Rock and Current River	18	90
				Black Rock and points on Upper Black River below Corning Bridge.	20	

Summary of commerce reported.

Articles.	1896.		1895 (tons).	1894 (tons).
	Estimated value.	Tons.		
Cotton	$348,660	2,181	1,473	2,545
Cotton seed	7,840	980	6,320	1,524
Hides and skins	4,500	60	96	19
Live stock	2,480	62	57	59
Lumber by steamboat	64,560	12,912	12,640	9,710
Staves and bolts	21,114	5,865	8,171	17,412
Provisions	161,600	1,010	2,694	632
Grain	7,380	738	495	372
Miscellaneous freights	81,800	818	578	1,808
Spokes			437	1,780
Saw logs by steamer	10,080	5,040	3,200	
Lumber by flatboat			200	
Saw logs by raft	134,066	67,033	80,731	39,300
Saw logs by flatboat	8,000	4,000		
Railroad ties by steamer	10,260	3,800	5,108	
Railroad ties by raft	9,000	3,334	8,333	12,375
Piling by raft	13,200	2,400	400	
Square timber by raft	6,897	1,045	1,500	
Total	891,437	111,278	132,433	87,536

Classification and distribution of commerce reported.

Between points on—	Tonnage.		Value.	
	By rafts and flatboats.	By steamboats.	By rafts and flatboats.	By steamboats.
Black River and Poplar Bluff		3,542		$41,288
Black River and Moark, Corning, and Knobel	18,400		$45,200	
Black River and Black Rock	29,217	19,304	59,600	208,461
Current River and Black Rock	25,762	880	57,497	34,160
Black River and Newport	2,023	6,515	4,046	300,731
Current River and Newport	2,000	3,225	4,000	135,634
Black River and Devalls Bluff	410		820	
Total	77,812	33,466	171,163	720,274

Comparison of totals of commerce reported.

	1896.	1895.	1894.
	Tons.	*Tons.*	*Tons.*
By steamers	33,466	41,269	35,861
By rafts or flatboats	77,812	91,164	51,675
Total	111,278	132,433	87,536

U 5.

IMPROVEMENT OF CURRENT RIVER, ARKANSAS AND MISSOURI.

The appropriation of August 17, 1894, was based upon a report made to comply with the requirements of the river and harbor act of September 19, 1890. The report was printed in House Ex. Doc. No. 157, Fifty-first Congress, second session, and in Annual Report Chief of Engineers for 1891, pages 2065–2071.

Original condition.—Between the mouth and 2 miles below the State line snags and overhanging timber were the obstructions to navigation; above this point gravel shoals were added to the list.

Object.—To improve the navigation of the river from the mouth to Vanburen, Mo. (95 miles).

Project.—To remove logs and snags from channel; to cut and deaden overhanging timber, and to contract water width at worst shoals by wing dams.

Work done in previous years.—In 1855 the State of Missouri appropriated $10,000 for the improvement of this stream. The first expenditure was in 1857, when some snags were removed and some timber cut. In 1872 another State appropriation ($20,000) was expended in building wing dams, removing snags, and cutting timber.

The first work done by the United States was in 1873, and was confined to reaches above the Arkansas and Missouri State line. It consisted of removing snags and cutting timber, building new and repairing old wing dams. Subsequent operations below the State line in fiscal years 1882 and 1883 were confined to the usual snagging operations. No further work was done until the appropriation of August 17, 1894, became available.

Abstract of work done by the United States.

Fiscal year.	Snags removed.	Trees cut.	Linear feet dam built.	Remarks.
1873	123	592		Above Arkansas and Missouri State line.
			629	At Kittricks Mill.
			86	Shore protection at Kittricks Mill.
			325	At Doniphan Shoal.
1882	180	300		Between mouth and Little Black River Cut-off (32 miles).
1883	85			Between mouth and Schumachers Landing (23½ miles).
1895	582	698		Between mouth and Jim Johnsons (25 miles).

Operations during this fiscal year.—The U. S. snag boat *Riverside* (hand propelled) was towed by the steamer *Portia* from Black Rock, on Black River, to the mouth of Current River, arriving there on the 13th of September, 1895, when snagging operations were begun. Operations closed December 20, 1895, when the boat was returned to Black Rock

and laid up January 4, 1896. The work extended over 64 miles of river, a point 11 miles above Doniphan, Mo., being the upper end of the work. Four hundred and seventy-three snags were removed and 112 trees cut.

Channel.—From the mouth to Johnsons Landing (25 miles) the river is in good condition and can be navigated night or day the entire year by boats of not over 3½ feet draft. The operations from Johnsons Landing to the upper limit of work was done with a view to aiding the rafting interests, and when work was suspended a good rafting channel and a fair steamboat channel existed in this part of the river when there was water sufficient for such navigation.

The approved project contemplated the improvement of this stream to Van Buren, Mo., a point 31 miles above the upper limit of work done under present appropriation. This project also contemplated the contraction of water widths at the worst shoals by wing dams. The money expended so far has been expended altogether in removing obstructions from the channel and in cutting overhanging timber. The appropriation of $2,000 in act of June 3, 1896, completes the amount originally estimated as necessary to complete project. Every rise adds new obstructions to this stream and it will require about $2,000 a year to maintain the channel already opened up.

Commerce.—A packet boat out of Newport makes weekly trips all the year on this stream to Johnsons Landing. Other boats occasionally come into the river for timber or staves. The bulk of the commerce is rafted, and of this complete information has not been received.

APPROPRIATIONS.

The early examinations of this river were made under appropriations for this in combination with other streams. The independent appropriations for this stream are as follows:

June 2, 1872, Current River, Missouri	$5,000.00
March 3, 1881, Current River, Arkansas and Missouri	2,000.00
August 17, 1894, Current River, Arkansas and Missouri	8,000.00
June 3, 1896, Current River, Arkansas and Missouri	2,000.00
Total	17,000.00
Received on account of deposit made by Capt. Wm. L. Sibert	2.00
Grand total	17,002.00
Expended to June 30, 1895	10,559.89

Money statement.

July 1, 1895, balance unexpended	$4,442.11
Amount appropriated by act of June 3, 1896	2,000.00
	6,442.11
June 30, 1896, amount expended during fiscal year	2,797.80
July 1, 1896, balance unexpended	3,644.31
July 1, 1896, outstanding liabilities	150.00
July 1, 1896, balance available	3,494.31

COMMERCIAL STATISTICS.

Through the low-water season this river was reported navigable for 16-inch boats to a point 11 miles above Doniphan, Mo., for 18-inch boats to Little Black River, for 24-inch boats to 6 miles above Johnsons Landing, and for 3-foot boats to Johnsons Landing.

List of stern-wheel boats that navigated Current River from May 31, 1895, to June 1, 1896.

Name.	Tonnage.	Loaded draft.		Between—	Round trips.	Passengers.
		Steamer.	Barges.			
		Ft. in.	*Ft. in.*			
A. R. Bragg	162.71	3 6	.....	Newport and Johnsons Landing.	52	464
G. M. Sivley	98.94	5 0	5 0	Newport and (?)	.....	1
Black Diamond	18.40	3 0	3 6	Black Rock and Johnsons Landing; Black Rock and Little Black River.	18	40

Summary of commerce reported.

Articles.	1896.		1895.
	Estimated value.	Tons.	Tons.
Cotton	$114,740	719	875
Cotton seed	3,384	423	550
Lumber by steamer	1,460	292	960
Lumber by flatboat	.....	.....	66
Staves and stave bolts	4,950	1,375	4,225
Grain	3,300	330	175
Provisions	32,000	200	540
Miscellaneous freights	8,600	86	65
Spokes	.....	.....	437
Saw logs by steamboat	1,360	680	.....
Saw logs by flatboat	4,000	2,000	.....
Saw logs by raft	42,100	21,050	13,479
Railroad ties by raft	4,500	1,667	8,333
Square timber by raft	6,897	1,045	1,500
Total	227,291	29,867	31,205

Classification of commerce, 1896.

	Estimated value.	Tons.
By steamboat	$169,794	4,105
By raft and flatboat	57,497	25,762
Total	227,291	29,867

U 6.

IMPROVEMENT OF ST. FRANCIS RIVER, ARKANSAS.

Original condition.—Below Marked Tree snags, leaning trees, and shoals obstructed navigation. Above Marked Tree, through the Sunk Lands, the channel meandered through cypress brakes, beds of smartweed, and in many places the waters were divided by sloughs and chutes.

Object of improvement.—Originally to improve navigation below Lesters Landing (232 miles), later to extend improvement (73 miles) to the town of St. Francis, Ark., now to improve navigation between Kennett, Mo., and the mouth of the river (279 miles).

Project.—The usual snagging operations and closing of chutes and sloughs.

Work done in previous years.—Work done on this stream has been under the heads of improvement of White and St. Francis rivers and that of improving St. Francis River, Arkansas. The abstract below contains that done under both heads, except closing of sloughs and chutes.

Abstract of work done.

Fiscal year.	Snags removed.	Trees cut.	Trees deadened.	Drifts removed.	Remarks.
1872	431	151	.....	2	Worked from mouth up to (?).
1874	36	76	.....	.....	Between mouth and Wittsburg.
1880	130	1,201	.....	11	Between Madison and Little River.
1881	*259	523	.....	.....	In lower reaches.
	*1,655	1,294	697	.....	Between Lesters Landing and Wittsburg.
1882	*363	.....	.....	.....	Between mouth and Wittsburg.
1883	562	866	.....	3	Between Wittsburg and Cut-off.
1885	88	2,993	.....	.....	Between mouth and Madison.
	196	653	.....	.....	Between Wittsburg and foot of Sunk Lands Lake.
1886	1,961	1,863	.....	4	Between foot of lake and town of St. Francis.
1887	195	4	.....	.....	Between L'Anguille River and Madison.
	621	210	.....	.....	Between Marked Tree and St. Francis.
1888	31	24	.....	.....	Near head of Dunklin County Cut-off.
1889	*47	.....	.....	1	Between Kennett and St. Francis.
1890	.....	.....	.....	.....	New hull built for A. B. Johnson.
1891	69	48	.....	.....	Between St. Francis and mouth of Little River.
1892	205	.....	.....	.....	Between Madison and Cut-off.
1893	1,046	446	.....	9	Between Madison and mouth.
1894	770	5,298	.....	1	Between Madison and Marked Tree.
1895	524	2,321	.....	1	Between Madison and mouth.
	*441	.....	.....	.....	Between foot of lake and Bertig.

*Includes snags, logs, stumps, and cypress knees.

Operations during this fiscal year.—July 1 to 5, 1895, snag boat *Johnson*, hand propelled, lying at Madison, Ark., was prepared for active operations and a second capstan was placed on the boat. July 6 operations were commenced, working upstream. August 10 the snag boat reached Wittsburg and started back down the river, arriving at Madison on the 24th of the month. By these operations 278 snags were removed, 105 trees cut, 3 drift piles were broken up, and 1 wreck in Allens Bend removed. Continuing down the river, the snag boat reached foot of Cut-off September 2, and began working upstream, arriving at Madison October 29, when operations were stopped on account of exhaustion of funds. By the operations below Madison 415 snags were removed and 324 trees cut. The heaviest work was between mouth of Black Fish and foot of Cut-off; here, in a distance of 1 mile, twelve working days were spent in removing 106 snags and cutting 45 trees.

The snag boat *Missouri* arrived at Bertig on the 1st day of July, 1894, and lay there until the 5th of the month, awaiting the completion of the drawspan of the Paragould Southeastern Railway Bridge. On the 17th of the month the boat reached the mouth of Dunklin County Cut-off, the division between St. Francis River, Arkansas, and St. Francis River, Missouri. Fifty-seven snags were removed.

By the combined operations of the *Johnson* and *Missouri* 752 snags were removed, 429 trees cut, 3 drift piles broken up, and 1 wreck removed. The work extended over 84.5 miles of river.

The snag boat *Johnson* was operated on the lowest possible stage, having to be pulled over the following crossings: Foot of Burnt Cane Bend, foot of Creelys Bend, head of Taylors Bend, head of Anderson Bend, Quigleys and Cups, and was also pulled over Cow Creek Bar.

The snag boat *Missouri* was operated at a stage about 2 feet above extreme low water.

Channel.—I have not had plant or funds available to inspect this stream during the past year.

Commerce.—Full report of the commerce on this stream below Marked Tree has not been obtained in response to repeated inquiry. The greater part of the commerce reported is such as arises from timber

industries, the largest item in tonnage being saw logs, which is about 73 per cent of the entire commerce reported. In the Sunk Lands the commerce by steamboats and that by rafting and flatboat is about equal in tonnage, and plantation products and supplies are in larger proportion than that on the lower river. Some commerce has been developed in the upper part of the Sunk Lands in the vicinity of the Paragould Southeastern Railway Crossing.

On the lower river, between Wittsburg and Helena, and between Marked Tree and Helena, an effort has been made to establish a light-draft "barge line" for the purpose of handling cooper stuffs and rough lumber. It has apparently met with some degree of success. Plantation supplies as incoming freights and plantation products as outgoing freights is the commerce of packet boats running out of Memphis, Tenn. The amount has not been learned. In the "Summary of commerce reported" is the item 34,000 tons of saw logs by steamboat. Of this, 32,000 tons was for the St. Louis, Mo., market. These logs are rafted on the lower river to a point where the Mississippi River boats can reach them, at which point they are loaded onto barges. In high-water stages the loading is done at Cut-off, 35 miles above the mouth, and in medium stages at Phillips Bayou, 4 miles above the mouth.

The work of improvement is reported by steamboatmen as lengthening the time of navigation about two months.

APPROPRIATIONS.

The earlier examinations and the earlier operations were made under appropriations for this in conjunction with other rivers. Of the expenditures under these appropriations this office has no record.

The separate appropriations are as follows:

March 3, 1871	$10,000.00
June 14, 1880	5,000.00
July 5, 1884	12,000.00
August 5, 1886	8,000.00
August 11, 1888	4,000.00
September 19, 1890	4,000.00
August 17, 1894	*83,000.00
June 3, 1896	8,000.00
Total	134,000.00
Received on account of deposit made by Capt. H. S. Taber, 1894	.16
Grand total	134,000.16
Expended to June 30, 1895	45,685.72

Money statement.

July 1, 1895, balance unexpended		$5,314.44
Amount appropriated by act of June 3, 1896		8,000.00
		13,314.44
Reserved in United States Treasury for freight charges	$0.55	
June 30, 1896, amount expended during fiscal year	4,971.00	
		4,971.55
July 1, 1896, balance unexpended		8,342.89
July 1, 1896, outstanding liabilities		100.00
July 1, 1896, balance available		8,242.89
Amount (estimated) required for work annually		8,000.00
Amount that can be profitably expended for maintenance in fiscal year ending June 30, 1898		8,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		

*Seventy-five thousand dollars of this, by the conditions of the act, to be expended by the Mississippi River Commission.

COMMERCIAL STATISTICS.

For boats of 2 feet draft the river was reported navigable from Bertig to Marked Tree, six months; from the mouth to Wittsburg, seven months, and a short reach of about 20 miles from Marked Tree, downstream, all the year.

Name.	Class.	Tonnage.	Draft (loaded).		Between—	Round trips.	Passengers.
			Steamers.	Barges.			
			Ft. in.	*Ft. in.*			
Delta	Stern-wheel.	35	2 0	3 0	Bertig and Lake City	25	
Ike	...do	66.19	2 0	2 6	Lake City and Marked Tree.	50	250
					Lake City and Bertig	1	5
Tom Young	...do	15.04	2 4	2 0	Marked Tree and Lake City.	20	
					Marked Tree and points below.	(?)	
Emma No. 2	...do	28	2 4	3 0	Wittsburg and Helena	75	
Ella*	...do	3	2 4				
Memphis	...do	210	5 0	4 0	Memphis and Tyronza R.	1	
Henrietta†	...do	99	4 0	4 0	Marked Tree and Helena.	8	
Ora Lee	...do	189.34	5 0		(No report)		
Louis Houck	...do	620.46	6 5	6 6	St. Louis, Mo., to (?)	(?)	
Rambler	...do	22.07	3 0		(No report received)		

*Fish boat.

†Began navigating this river March 28, 1896.

Summary of commerce reported.

Articles.	1896.		1895 (tons).	1894 (tons).
	Estimated value.	Tons.		
Cotton	$92,000	575	382	125
Cotton seed	5,848	731	1,172	60
Hides	225	3	10	2
Live stock	12,000	300	61	45
Provisions	120,160	751	271	52
Grain	2,800	280	734	43
Miscellaneous freights	10,600	106	1,023	1
Saw logs by steamboat	68,000	*34,000	16,000	
Saw logs by flatboat	100	50		
Saw logs by raft	19,300	†9,650	5,000	12,000
Staves by steamboat	13,380	3,716	7,569	5,860
Staves by flatboat	7,985	2,218	300	
Lumber by steamboat	27,450	5,490	4,585	575
Lumber by flatboat	500	100		
Lumber by raft	400	100		1,000
Railroad ties by flatboat	4,709	1,670		
Total	385,457	59,740	38,107	19,763

*32,000 tons of this by Mississippi River towboats.
†6,000 tons of this reported as coming out of Little River.

Classification and distribution of commerce reported.

	By raft and flatboat.		By steamboat.	
	Tons.	Estimated value.	Tons.	Estimated value.
In the Sunk Lands	3,489	$25,740	3,199	$137,150
Below the Sunk Lands	10,404	22,255	42,648	200,312
Total	13,893	47,995	45,847	337,462

U 7.

IMPROVEMENT OF ST. FRANCIS RIVER, MISSOURI.

The first appropriation under this head was based upon report of an examination made to comply with the requirements of river and harbor act, August 5, 1889. This report is printed in the Annual Report of the Chief of Engineers for 1887, page 1549.

Original condition.—Channel obstructed by snags, drifts, drift shoals, and overhanging timber. In the upper reaches by gravel shoals.

Object of improvement.—Originally to improve navigation between the towns of St. Francis, Ark., and Greenville, Mo. (102 miles). Later to include the river from St. Francis, Ark., down to Kennett, Mo. (26 miles), in this improvement.

Project.—The usual snagging operations.

Work done in previous years.—Although the original estimate and the basis for the first appropriation contemplated removal of gravel from the shoals lying within 12 miles of Greenville, this work was never included in the projects for expending the various appropriations, thus leaving snagging operations as the work of past years.

Operations this fiscal year.—On July 17 the snag boat *Missouri* (hand propelled) began operations at the foot of Dunklin County Cut-off. From here the work was carried up to Whittaker Cut-off, about 4 miles above St. Francis. From the foot of Dunklin County Cut-off to the head of Seven Mile Island (16 miles) the river was very badly obstructed by fallen timber and large accumulation of drift. Three months were spent in working over this portion of the river.

By the operations during the year, 831 snags and 680 logs were removed from the channel, 80 trees cut, and 99 drifts broken up.

COMMERCE.

The commerce of this river is that arising solely from lumber and stave industries. It centers at the towns of Poplin and St. Francis.

CHANNEL.

From foot of Dunklin County Cut-off to the town of St. Francis the minimum channel opened by the snag boat *Missouri* during the past year was 24 feet wide and 3 feet deep. This minimum occurs at six places. The river is narrow and crooked, and throughout its entire length the channel is seriously obstructed by snags and logs at medium and low stages. At high stages overhanging timber greatly interferes with steamboat navigation. Above Chalk Bluff the river is navigated at medium and high stages only.

APPROPRIATIONS AND EXPENDITURES.

This reach of river is understood not to have been included in the snagging operations under the early appropriations for snagging in Western rivers.

Its specific appropriations and other funds are as follows:

Appropriation August 11, 1888	$5,000.00
Appropriation September 19, 1890	10,500.00
Received from sale of U. S. snag boat *Missouri*	3,000.00
Appropriation August 17, 1894	5,000.00
Total	23,500.00
Expended to June 30, 1895	17,433.06

Money statement.

July 1, 1895, balance unexpended	$6,066.94
June 30, 1896, amount expended during fiscal year	3,848.06
July 1, 1896, balance unexpended	2,218.88
July 1, 1896, outstanding liabilities	150.00
July 1, 1896, balance available	2,068.88

COMMERCIAL STATISTICS.

Chalk Bluff was reported as the head of low-water navigation from July 25, 1895, to December 16, 1895, for boats drawing 2 feet.

List of boats engaged in navigating St. Francis River, Mo., June 1, 1895, to May 31, 1896.

Name.	Class.	Tonnage.	Draft.		Between—	Round trips.
			Steamers.	Barges.		
			Ft. in.	*Ft. in.*		
Roy No. 2	Stern wheel.	(*)	(*)	(*)	Poplin and (?)	(*)
S. A. Stroud	....do	35.28	2 0	3 0	St. Francis and Stolpers	150
					St. Francis and Poplar Creek	10
Milt. Janes	....do	25.54	2 7	3 0	St. Francis and Big Drift	10
Emma No. 2†	....do	28.00	2 6	3 0	.....do	10

* No report. †The steamer *Emma No. 2* left this river in July, 1895.

Summary of commerce reported.

Articles.	1896.	1895.	1894.
	Tons.	*Tons.*	*Tons.*
Lumber	700	3.100	3,402
Staves and stave bolts	9,660	7,106	20,275
Provisions	.....	50	6
Grain	.....	11	180
Miscellaneous freights	.....	59	160
Spokes	2,100	.....	1,901
Saw logs (by steamers)	.....	.....	482
Saw logs (rafted)	13,400	12,000	9,400
Piling (rafted)	762	.....	.....
Railway ties (rafted)	42	.....	.....
Total	26,664	23,326	35,826

	Tons.
Rafted tonnage centering at St. Francis	8,842
Rafted tonnage centering at Poplin	5,362

This river is crossed near Wappapello by the Cape Girardeau and Fort Smith Railway; at Poplin by the Poplar Bluff and Cairo Branch of the St. Louis, Iron Mountain and Southern Railway, and at St. Francis by the St. Louis Southwestern Railway.

U 8.

REMOVING SUNKEN VESSEL OR CRAFT OBSTRUCTING OR ENDANGERING NAVIGATION.

Report having been made that the wreck of the steamer *Eli* at the steamboat wharf at Little Rock was an obstruction to and endangered navigation in the Arkansas River, and this wreck having been permitted by the owner to remain to the injury of navigation for a longer period than two months, there was, on June 3, 1895, allotted from the

indefinite appropriations made available by section 4 of the act of June 4, 1880, the sum of $300 to pay the expenses of removing the said wreck.

The snag boat *Beauregard* began removing this wreck June 26, and completed the work July 2. The entire allotment was expended.

U 9.

PRELIMINARY EXAMINATION OF UPPER WHITE RIVER, ARKANSAS, TO DETERMINE THE PROPER METHOD OF IMPROVEMENT.

[Printed in House Doc. No. 98, Fifty-fourth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., November 29, 1895.

SIR: I have the honor to submit the accompanying copy of report, dated September 14, 1895, by Lieut. William L. Sibert, Corps of Engineers, giving the results of a preliminary examination of upper White River, Arkansas, to determine the proper method of improvement, provided for by the terms of the river and harbor act of August 17, 1894.

It is the opinion of Lieutenant Sibert that the upper White River is worthy of improvement, also that the proper method of improving all of it except the alluvial portion is by means of locks and fixed dams. The division engineer, Col. H. M. Robert, Corps of Engineers, concurs in the opinion of the local officer that the upper White River is worthy of improvement by the United States from Batesville, Ark., to Buffalo Shoals, a distance of about 89 miles, and that the proper method of improvement is by locks and dams. In the opinion of Colonel Robert the remainder of the upper White River is not worthy of improvement just now.

This river is capable of improvement from the engineer's point of view, but the information at hand does not convince me that the needs of commerce justify the expenditure of public money upon it at this time. In the words of the law, I must therefore say that in my judgment the stream is not worthy of improvement.

Very respectfully, your obedient servant,

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

Hon. DANIEL S. LAMONT,
Secretary of War.

REPORT OF FIRST LIEUT. W. L. SIBERT, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Mount Nebo, Ark., September 14, 1895.

SIR: In compliance with instructions contained in letter from your office dated August 20, 1894, I have the honor to submit the following report concerning the proper method of improving upper White River, Arkansas, as called for in section 10 of the river and harbor act of August 17, 1894:

From the mouth of White River to the point where Black River enters White the depth available for navigation is seldom less than 3½ feet. From this point up White River the fall per mile increases and the available depth during low-water season decreases. The mouth of Black River is therefore considered in this report as marking the dividing line between upper and lower White River.

Proceeding up White River from the mouth of Black, the valley is alluvial for about 20 miles, and from that point up the river assumes the characteristics of a mountain stream, the banks becoming stable, the valley becoming narrower, the river sometimes running through gorges with vertical cliffs of rock on both sides.

The principal obstructions to low-water navigation below Batesville are gravel bars forming low dams across the river. Above Batesville these bars or dams are sometimes gravel, sometimes gravel and bowlders, and sometimes solid rock.

From the mouth of Black River to Batesville the fall per mile is 0.978 foot. From Batesville to Buffalo Shoals the fall per mile is 1.648 feet. From Buffalo Shoals to Forsyth, Mo., the fall is about 2.33 feet per mile.

The low-water discharge above Batesville was determined last year to be about 1,300 cubic feet per second. No high-water discharge has ever been determined. The high-water mark is known at several places, and 260,000 cubic feet per second is submitted as an approximation, the mean high-water velocity being assumed at 6.25 miles per hour. There has been no high water in White River this season.

There are two recognized methods of permanently improving the navigation of a stream—one by regulating the width, form, and slope of the river by means of dikes, training walls, bank protection, etc., and one by means of locks and dams.

Some work has been done on this river, classible under the first method of improvement. This work has been done with a view to the improvement of certain shoals, but no methodical plan for the improvement of the river, viewed as a whole, has been attempted by this method, the rate of appropriations not warranting it.

The testimony of the steamboat men is that the navigation season has not been prolonged any by this work. A table is submitted below showing the depths at low water on the ruling shoals between Batesville and Calico Rock before improvement and the depths at present. The depths of 1874 are taken from a report to Major Suter by R. J. Dukes; the present depths are based on the statement of Captain Warner, steamer *Dauntless* (draft, light, 8 inches).

The third column of gauge readings is from soundings actually taken under my direction, gauge about 2 feet. The miles in the table are distances above Newport, Ark., by survey of 1885.

Name of shoal.	Miles.	Depth, 1874.	Depth, 1895.	Depth, 1895 (gauge 2 feet).	Nature of bottom.
		Inches.	*Inches.*		
Cornwall	48	18	8	2 feet	Gravel.
Maxwell	49	.....	14	.....	Do.
Dark Corner	52	.....	7	2 feet	Do.
Ehrenhardt	52.3	.....	7	19 inches	Do.
Slip up Bar	56	.....	6	25 inches	Do.
Batesville Shoal	61	.....	20	3 feet	Bowlders.
Cajin	70	12	7	22 inches	Gravel.
Dry Creek	71	18	12	23 inches	Do.
Wild Haws	73.5	11	6	2 feet	Gravel (probably rock under).
Porter Hodge	76.8	12	20	20 inches	Gravel and bowlders.
Round Bottom	80.5	30	18	27 inches	Gravel, rock, and bowlders.
Mary Harris	86.8	6	18	25 inches	Gravel.
Wooten (Perrin)	87	10	18	3 feet	Do.
Mount Olive (lower)	89.8	6	8	25 inches	Gravel (probably rock under).
Mount Olive (upper)	90.5	6	20	.....	Bowlders.
Fish Trap	94	6	10	26 inches	Bowlders and gravel.
Piney	95.8	9	12	23 inches	Do.
White House	97.7	12	9	3 feet	Gravel.

R. J. Dukes mentions other shoals, but since the comparison of methods of improvement is based on the reach from Batesville to Calico Rock, the other shoals are not included in this list.

The soundings taken when water was 2 feet on the gauge show that a 2-foot rise in the river does not increase the depths on the shoals by that amount.

Of the above-named shoals contraction works have been erected at the following:

Cornwall.—One rock wing dam, 230 feet long, on left bank; built fiscal year 1892. Present condition: Washed to 0.5 foot below low water; dangerous to navigation.

Dark Corner.—One brush and gravel wing dam, 462 feet long, across chute on left; one brush and gravel dam, 50 feet long, across chute on right. Both built in fiscal years 1885–86; rebuilt in fiscal year 1887; repaired in fiscal year 1890. Present condition: Dam on left bank has two breaks in it, remaining portion 0.5 foot above low water; dam on right bank is in good condition, 3 feet above low water.

Ehrenhardt.—One stone, gravel, and brush wing dam, 512 feet long, on right bank; one stone, gravel, and brush wing dam, 448 feet long, on left bank; built fiscal year 1885. The 448-foot dam, on left bank, was lengthened to 700 feet in fiscal year 1887. One gravel, stone, and brush wing dam, 115 feet long, on right bank, was built in fiscal year 1890. Present condition: No trace of the 512-foot dam on the right bank; barely a trace of the 700 foot dam on the left bank. The 115-foot dam is in good condition, 3 feet above low water.

Batesville Shoal.—One brush and gravel dam, 294 feet, across chute on right; built in fiscal year 1883; repaired in fiscal year 1887. Present condition: Useless.

Wild Haws—One gravel, stone, and brush wing dam 885 feet long on left bank; one gravel, stone, and brush wing dam 1,120 feet long on right bank. Built in fiscal year 1887. Present condition: For the first 500 feet from shore the dam on right bank is in fair condition and is 2.5 feet above low water; the remainder of this dam is washed flat to low water; of the dam on the left bank practically nothing remains.

Round Bottom.—Four stone wing dams, 56 feet, 345 feet, 132 feet, and 136 feet long, on left bank, built in fiscal years 1883 and 1887. Present condition: Barely a trace of the 56 foot dam; 132-foot dam entirely gone; 345-foot dam is washed flat to 0.5 foot above low water; 136-foot dam is gone entirely.

Mary Harris.—One stone wing dam 140 feet long on right bank and one 350 feet long on left bank, built in fiscal year 1887. Present condition: Dam on right bank is gone; dam on left bank is partly good, one hole, 40 feet, washed out midway; about 200 feet remains to a height of 3 feet above low water.

Wooten (Perrin).—One stone wing dam 192 feet long on left bank, built in fiscal year 1886, raised in fiscal year 1887. One stone wing dam 19.2 feet long, built on right bank in fiscal year 1887. Present condition: Dam on right bank is gone; dam on left about 1 foot above low water.

Fish Trap.—One stone wing dam 388 feet long on left bank, built in fiscal year 1887. Present condition: About 0.5 foot above low water.

Piney.—One stone wing dam 418 feet long on right bank, built in fiscal year 1887. Present condition: Only 150 feet of shore end left, and it is about 1 foot above low water.

White House.—One gravel, stone, and brush wing dam 850 feet long on right bank, one 700 feet long on left bank, built in fiscal year 1887. Present condition: Both dams washed down to low water and are covered with gravel.

Sams.—Two stone, gravel, and brush dams 313 feet and 175 feet long across chutes; built in fiscal year 1881, rebuilt in fiscal year 1887. Present condition: Of the 313-foot dam, 63 feet is gone and the remainder washed to 0.5 foot above low water. The 175-foot dam is entirely gone.

A comparison of the available depths of 1874 with those of 1895 and the record of the dams lost do not show favorably for contraction, or at least for an attempt to improve a river as a whole by contracting certain places only, unless those places are markedly abnormal.

The experience derived from the attempts made to improve rivers by contraction seems to be that it is impracticable to destroy the stair-like profile of a stream and to create a uniform slope in the bed of the river, but that we must accept at the outset the fact that the stream will forever consist of pools and falls at low water, and that in addition to contracting the river to a calculated width we must also so shape the

bottom and banks above and below a crossing as to reproduce the observed conditions at the naturally good crossings in the stream. To make a close estimate for an improvement of this character requires more data than is in the possession of this office.

* * * * * * *

The country tributary to this river is largely undeveloped, and the largest amount of the present commerce is timber in its various forms. To be forced to pass rafts through a lock every 10 miles would be troublesome, and considering only the rafting interests it would be desirable to either improve this river by contraction or let it remain as it is.

However, if there is to be no future development in this country, and the ever-decreasing timber interests are to be the guiding element, the river is not worth improving by either method.

This river runs through a mountainous country which is rich in minerals. The bottom lands are small in extent, but fertile.

The high table-lands on either side of the river are a part or could be made part of the famed fruit growing section of northwestern Arkansas, the apples from which section were awarded the first premium at the World's Fair at Chicago.

I tried to obtain some technical data concerning the zinc, marble, lead, and manganese in this section, but was unable to do so.

That there are large and valuable deposits of manganese, carbonate of zinc, and many square miles underlaid with marble, can, in my opinion, be accepted as a fact. A specimen of carbonate of zinc from this section weighing 12,000 pounds was exhibited at the World's Fair at Chicago and was awarded the first prize, being less than 1 per cent under theoretically pure zinc ore. This zinc is being marketed on a small scale, transportation facilities not warranting much development. The manganese in the Batesville district is being worked, a railroad having been extended from Batesville into the manganese deposits near there.

The marbles from this section have been tested by the Smithsonian Institution, and they compare favorably with Tennessee and Georgia marbles.

There are no railroads in this section above Batesville, due probably to the excessive cost of construction through a rough, mountainous country, and the river is the only artery of commerce for a section of country approximately 200 miles long and 200 miles wide.

If the transportation of minerals, such as zinc and lead ores, and manganese and marble will in the future constitute the bulk of the commerce, a 3-foot channel obtained by contraction, with its swift current and narrow channel, would not be the most desirable, because heavy freights are most economically shipped by barges, and anything less than 4 feet is not an economical depth for such shipments; and since the future development, which will probably be in the direction outlined above, is the only grounds upon which a systematic improvement is justifiable, the improvement by locks and dams is in my opinion the best method.

It should be stated that the improvement of a river by regulating its channel is not always successful, and that a great many failures have been recorded, due probably to the fact that the laws governing the flow of water in rivers are not thoroughly known, and in my opinion the experiment on upper White River would be a doubtful one, considering the small discharge and the nature of the obstructions.

Canalization is a well known, well tried, and certain method if the work is well done and the banks of the stream are stable.

Movable dams are of course preferable to fixed ones, but the extreme cost of using such dams, with their small admissible height in a river with the fall of the upper White, precludes their consideration in this discussion.

Fixed dams will, undoubtedly, have a tendency to gradually fill up the pools in the completed system. Green, Barren, and Kentucky rivers in Kentucky, however, were improved by locks and fixed dams about fifty years ago, and outside of the annual spring dredging to clean out the entrances to the locks I do not think that navigation has been interfered with by the filling of the pools. Upper White River and the upper parts of the rivers mentioned above have somewhat similar characteristics, and the United States is continuing the same system on those streams without fear of the filling of the pools interfering with navigation, at least during the life of the proposed improvements.

In my opinion upper White River is worthy of improvement; also that the proper method of improving all of it except the alluvial portion is by means of locks and fixed dams. The fall per mile in the alluvial part is about 0.978 feet, and if careful surveys do not disclose locations for locks where the banks are stable and suitable foundations can be made, this portion had best, in my opinion, be improved by regulation works.

In my opinion, Buffalo Shoals should be the upper limit of the improvement for the present at least.

Although lower White River has water sufficient for navigation the year round, there are no through steamboat lines on it.

Memphis and St. Louis are the markets for the section of the country under consideration, but the White River parallels the Mississippi to such an extent that from Newport, 6 miles below the mouth of Black River, to Memphis by water is 421 miles, while it is 98 miles by railroad. So the railroads have won on the through traffic.

The existence of the river has considerable effect on freight rates, however. From Newport, Ark., to Batesville a railroad parallels the White River (this road is a branch of the main line passing through Newport), and ordinarily there is very little steamboating between Newport and Batesville. It must be accepted in any scheme for improvement that so long as the markets for northwestern Arkansas remain to the north or east of that section the freights out of the upper White River Valley will be taken by the railroad at either Newport or Batesville, and that for the present the people in the upper White River Valley will derive, practically, as much benefit from improvements commencing at Batesville and extending up the river as if they commenced at the mouth of Black River.

While ultimately, in my opinion, the river will be worthy of improvement from the mouth of Black River to Buffalo Shoals, a distance of 116 miles, thus giving this section a competing all-water route to a possible Southern market, that part of it from Batesville, Ark., to Buffalo Shoals, a distance of 89 miles, should be improved first. If it be decided to improve by locks and dams, no further surveys are necessary to the preparation of a project with estimate for that portion of the river from Batesville to Buffalo Shoals. A survey at an estimated cost of $2,000 would be necessary in preparing a project for that portion from the mouth of Black River to Batesville.

A profile map* of upper White River (survey of 1885) is inclosed herewith.

Very respectfully, your obedient servant,

WM. L. SIBERT,
First Lieutenant of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.
(Through the Division Engineer.)

[First indorsement.]

U. S. ENGINEER OFFICE, SOUTHWEST DIVISION,
New York City, November 7, 1895.

Respectfully forwarded to the Chief of Engineers, United States Army. I concur in the opinion of Lieutenant Sibert that the upper White River is worthy of improvement by the United States from Batesville, Ark., to Buffalo Shoals, a distance of about 89 miles, and that the proper method of improvement is by locks and dams. Lieutenant Sibert states that no additional surveys are necessary for the preparation of a project with estimates for improving this portion of the river by locks and dams.

For the reasons given by Lieutenant Sibert I think that the question as to the worthiness of improvement of the remainder of the upper White River should be deferred until after the portion above recommended has been improved. It is not worthy of improvement just now, but whether it will be after the improvement recommended has been completed is another question which the future will answer.

HENRY M. ROBERT,
Colonel of Engineers, Division Engineer.

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*Not printed.

APPENDIX V.

REPORT OF CAPT. GRAHAM D. FITCH, CORPS OF ENGINEERS, UPON PRELIMINARY EXAMINATION OF WOLF RIVER, TENNESSEE, AND REPORT OF COLONEL G. L. GILLESPIE, CORPS OF ENGINEERS, PRESIDENT, MISSISSIPPI RIVER COMMISSION, UPON CAVING OF WEST BANK OF MISSISSIPPI RIVER IN FRONT OF HELENA, ARKANSAS.

V 1.

PRELIMINARY EXAMINATION OF WOLF RIVER, TENNESSEE, FROM ITS MOUTH TO A POINT FIVE MILES ABOVE.

[Printed in House Doc. No. 218, Fifty-fourth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., February 4, 1896.

SIR: I have the honor to submit the accompanying copy of report, dated January 24, 1896, by Capt. Graham D. Fitch, Corps of Engineers, of the results of a preliminary examination of Wolf River, Tennessee, from its mouth to a point 5 miles above, made in compliance with the requirements of the river and harbor act of August 17, 1894.

For the reasons stated, I concur in the opinion of Captain Fitch that Wolf River is worthy of improvement by the General Government from the mouth to the lower railroad bridge, a distance of about 2 miles.

No survey is needed to enable a project and estimate of cost of improvement to be prepared.

Very respectfully, your obedient servant,

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

Hon. DANIEL S. LAMONT,
Secretary of War.

REPORT OF CAPT. GRAHAM D. FITCH, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., January 24, 1896.

GENERAL: In compliance with Department letter of August 20, 1894, addressed to Lieut. J. C. Sanford, Corps of Engineers, then in temporary charge of this office, I have the honor to submit the following report of a preliminary examination of "Wolf River, Tennessee, from its mouth to a point 5 miles above," required by the river and harbor act of August 17, 1894. Under the requirements of the river and harbor act of July 12, 1892, an examination of the lower 2½ miles of this river was made, and a report made thereon to the Chief of Engineers by Capt. S. W. Roessler, Corps of Engineers, under date of April 11, 1893. (See Report of the Chief of Engineers, United States Army, Appendix X 2, p. 2136.)

The condition of the river as to navigation has been somewhat improved since the date of Captain Roessler's report, by the expenditure of about $8,000 from the allotment of $10,000 for this purpose, made under the river and harbor act of August 17, 1894. The work done consisted of removing obstructions, such as piles, stumps, and sunken logs, from the mouth to a point about 8,200 feet upstream, and dredging through the bar at the mouth for a length of about 1,300 linear feet, in which length nearly 18,000 cubic yards of material was removed. Upon the completion of the dredging across the bar there was a navigable channel for boats drawing 3½ feet, when the river was at the lowest stage on record, viz, 2.4 feet below the zero of the Memphis gauge; but at this time the transfer boat of the Memphis and Little Rock Railroad attempted to wash out a basin to enable them to land at their incline, and caused a deposit in the upper end of the dredged channel sufficient to prevent the usual boats engaged in towing logs to the mills from entering. The snagging operations produced a navigable channel, to a point 1 mile above the mouth, for boats drawing 3½ feet, even at the lowest stage.

The business interests to be benefited by improving Wolf River are:

(1) The Memphis and Little Rock Railroad Company, which transfers annually about 25,000 cars.

(2) The sawmills, most of which are now located along the south bank in close proximity to each other up to a point 10,000 feet above the mouth, where a local railroad bridge with fixed span crosses the river and impedes steamboat navigation. The bridge just mentioned has been constructed for the purpose of giving the sawmills now located on the north bank a railroad connection for shipments of lumber. The mills on this stream represent an investment of $2,000,000.

About one-half of a mile above the lower railroad bridge is a fixed wagon bridge, and about one-half of a mile above this is the fixed bridge of the Chesapeake and Ohio Railroad. From thence to the 5-mile limit from the mouth there are no business interests at present, and the stream at low water is so shallow and full of obstructions as to be impassable for a skiff.

On account of the relative magnitude of the interests in this river dependent upon steamboat transportation, it is my opinion that Wolf River is worthy of improvement by the General Government from the mouth to the lower railroad bridge, a distance of about 2 miles.

* * * No further survey is needed to enable a project and estimate of cost of improvement to be prepared.

Very respectfully, your obedient servant,

GRAHAM D. FITCH,
Captain, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

V 2.

REPORT UPON THE CAVING OF THE WEST BANK OF THE MISSISSIPPI RIVER IN FRONT OF HELENA, ARKANSAS.

[Printed in House Doc. No. 316, Fifty-fourth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., March 16, 1896.

SIR: I have the honor to submit the accompanying copy of report of March 14, 1896, by Col. G. L. Gillespie, Corps of Engineers, president

of the Mississippi River Commission, in regard to the caving in of the west bank of the Mississippi River in front of Helena, Ark., together with a report by the district officer, Capt. Graham D. Fitch, Corps of Engineers, dated March 7, 1896, giving details and an estimate of the cost of the necessary protection work.

The reports indicate the urgent necessity for the work recommended by Captain Fitch and approved by Colonel Gillespie, and I respectfully recommend that they be submitted to Congress for its consideration.

Very respectfully, your obedient servant,

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

Hon. DANIEL S. LAMONT,
Secretary of War.

REPORT OF COL. G. L. GILLESPIE, CORPS OF ENGINEERS, PRESIDENT, MISSISSIPPI RIVER COMMISSION.

THE MISSISSIPPI RIVER COMMISSION,
PRESIDENT'S OFFICE, ARMY BUILDING,
New York City, March 14, 1896.

GENERAL: I have the honor to state that report was made to this office on the 21st ultimo that the west bank of the Mississippi River in front of Helena, Ark., was caving badly, and that the damage already done was serious enough to excite alarm for the safety of valuable public and private interests concentrated on the city front. The district officer was accordingly instructed to make an examination of the site and report the condition of the bank, the estimate of work necessary to be done for its protection, the degree of urgency which exists, and the estimate of cost for the execution of the works of protection.

I have the honor to invite attention to copy of his report, dated March 7, 1896, which embodies all the facts which he was requested to ascertain, and which is now forwarded to you for the information of the Secretary of War at the request of Hon. P. D. McCulloch, member of the Committee on Rivers and Harbors, House of Representatives.

It will be observed that the district officer reports that the work is "deemed urgent on account of proximity to the levee, which can not well be moved back, and also because the caving is in front of valuable business property."

This office concurs in the views of the district officer.

A print* of the survey will be forwarded when received from the secretary of the Commission.

Very respectfully, your obedient servant,

G. L. GILLESPIE,
Colonel, Corps of Engineers,
President, Mississippi River Commission.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

REPORT OF CAPT. GRAHAM D. FITCH, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., March 7, 1896.

COLONEL: In compliance with the instructions contained in your letter of February 26, I have the honor to make the following report of

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*Omitted.

the caving at Helena, Ark., based upon an examination and survey just completed. The location of the cavings is shown upon the map herewith transmitted.

The survey shows that the bank is caving at several points between stations 12 and 26, or along a length of about 2,800 feet, and that three of these caves occurred about a month ago, when the river was at about the two thirds stage.

The cavings are as follows:

1. Between stations 12 and 13, about 200 feet long by 60 feet back, approaching to within 20 feet of the base of the levee.

2. Between stations 15 + 50 and 17 + 60, about 400 feet long by 50 feet back.

3. Between stations 18 and 20, about 400 feet long by 60 feet back.

4. Between stations 22 and 24, about 350 feet long by 75 feet back. This occurred in 1894, and carried in part of the outside slope of the levee. The latter was repaired by the local levee board during the present fiscal year.

5. Slight caving is now taking place nearly opposite station 26.

The work placed by the Government during 1889 extended from the head of the elevator to a short distance below the box factory. This comprised one mattress and five dikes. Of the latter, two only were entirely finished, viz, Nos. 1 and 2. No. 3 lacked one crib. No. 4 had cribs placed at the bank end only, while No. 5 had only the sill mat placed. It appears that where this protection work was completed there has been no caving, the first caving occurring at Dike No. 4, which was incomplete. When the cribs of this were placed it was on a bank which had caved but a few weeks before, and consequently the foundation was quite unstable.

For the protection of the lower portion of the Helena front against further erosion, I therefore recommend the following:

1. That fascine mattresses, about 260 feet wide, be placed from the lower end of Dike No. 4 downstream for a distance of about 2,500 feet, paving the banks along there with riprap up to about the 20-foot stage.

2. That the cribs at Dike No. 4 be raised to about the original grade.

3. That two short brush and stone spurs be placed in the large pocket between stations 20 and 23, to break up the high-water eddy action there.

4. That the exposed ends of Dikes Nos. 1, 2, and 3 be repaired by the addition of stone where necessary.

The estimate of the cost of the above work is as follows:

1. For 2,500 linear feet of mat revetment, at $26	$65,000
2. For repairs to Dike No. 4	2,000
3. For two spurs between stations 20 and 23	6,000
4. For repairs to old spur dikes	2,000
Total required for the project	75,000

The work is deemed urgent, on account of proximity to the levee, which can not well be moved back, and also because the caving is in front of valuable business property.

Very respectfully, your obedient servant,

GRAHAM D. FITCH,
Captain, Corps of Engineers.

Col. G. L. GILLESPIE,
Corps of Engineers, U. S. A.,
President, Mississippi River Commission.

APPENDIX W.

REMOVING SNAGS AND WRECKS FROM MISSISSIPPI RIVER; IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS, OF HARBOR AT ST. LOUIS, MO., AND OF KASKASKIA RIVER, ILLINOIS.

REPORT OF MAJ. THOS. H. HANDBURY, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1 Removing snags and wrecks from Mississippi River.
2. Mississippi River between the Ohio and Missouri rivers.
3. Harbor at St. Louis, Missouri.
4. Kaskaskia River, Illinois.

UNITED STATES ENGINEER OFFICE,
St. Louis, Mo., July 13, 1896.

GENERAL: I have the honor to transmit herewith the annual report for the works under my charge for the fiscal year ending June 30, 1896.

Very respectfully, your obedient servant,

THOS. H. HANDBURY,
Major, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

W 1.

REMOVING SNAGS AND WRECKS FROM MISSISSIPPI RIVER.

Before this work was inaugurated the navigation of the river was very much interfered with by numerous snags, logs, etc., which had lodged in the channel, and to which a new accession was brought down on each rise of the river, thus constantly adding new and unknown obstructions to those already there. A large number of wrecks, dangerous to navigation, also occupied the channel. For the removal of these obstructions appropriations were made as early as 1824, and the project adopted consisted of building boats suitable for removing the snags, etc., and operating them by hired crews whenever the stage of water was favorable for the work and funds were available.

The total amount expended for this purpose can not be definitely given, as previous to the appropriations made by act of March 3, 1879, a general amount was appropriated to be applied to several streams as their needs required.

The first specific sum for removing snags, wrecks, etc., from the Mississippi River was appropriated by act of March 3, 1879, and was followed by other appropriations until 1888, when by the act of August 11 of that year an annual expenditure not to exceed $100,000 for this purpose was authorized. Under that act operations have since been carried on continuously.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1896.

The replating and other repairs to the hull of the snag boat *H. G. Wright* that were in progress at the end of the last fiscal year, under the contract with the Iowa Iron Works, approved March 18, 1895, to be completed August 1, 1895, were not finished until December 26, 1895. The cause of this delay is ascribed by the contractors to financial embarrassments and difficulties in getting necessary material.

Upon the completion of these repairs the boat was put in commission under command of Capt. R. E. Birch, and operated between St. Louis and Memphis from that date until March 31, 1896, making regular trips patrolling the river and removing such snags and other obstructions as were found in the way of boats navigating the river.

On April 1 and 2 the wreck of the steamer *Hudson* was removed from the channel opposite Dunklins Bluff. After this the boat was laid up in ordinary at Bushberg, Mo., for minor repairs, the water having risen to a stage when snagging work could not be done to advantage.

The snag boat *J. N. Macomb*, under command of Capt. Alex. H. Stewart, commenced work July 12, 1895, and continued operations between St. Louis and Natchez until April 15. Her principal duty was to patrol the river between Memphis and Natchez and remove snags and other obstructions to navigation. On this last date she was laid up in ordinary at Bushberg, Mo., for minor repairs, and for the reason that the river had risen to a stage when snagging work could not be advantageously done.

The work accomplished by the two boats during the fiscal year is given in the following table:

Name of snag boat.	Snags pulled.	Leaning trees cut.	Drift piles removed.	Wreck removed.	Miles run.
H. G. Wright	783	9,016	4	1	2,768
J. N. Macomb	2,196	10,632	7	.....	11,496
Total	2,979	19,648	11	1	14,264

The only wreck removed during the year, already referred to, was that of the steamer *Hudson* by the *Wright* on April 1 and 2 from the channel opposite Dunklins Bluff.

The trees referred to are generally leaning timber in bends of the river, or trees that are liable to fall into the stream and become obstructions.

An annual appropriation of an amount not to exceed $100,000 having been made for the work, the snag boats will patrol the river whenever necessary in order to keep the channel free from obstructions such as snags, logs, drift piles, leaning trees, and such small wrecks as they may occasionally be able to handle. The removal of large, heavy, or numerous wrecks by the snag boats is not contemplated, the boats not being built for such purpose or for wrecking. The removal of wrecks from the channels in general is provided for by a specific act of Congress.

Amount expended on this work to July 1, 1895, under all specific and annual appropriations, including that of March, 1879, $1,097,280.98.

Amount expended from current allotment during the fiscal year, including $100.32 outstanding liabilities, is $80,496.26. A detailed statement of this expenditure as required by law is given in the accompanying Tables 1 and 2. The total expenditures during the year, including the outstanding liabilities of $21,729.48 at the beginning of the year, were $102,225.74.

The work was all done by hired labor except that included in the contract with the Iowa Iron Works for repairs to the snag boat *H. G. Wright.* In general the material has been purchased from the lowest bidder for the most suitable article, after ten days' advertisement for proposals. In many cases this method was impracticable. Purchases were then made in open market in the manner usually pursued by private individuals.

The work done by the snag boats is of great benefit to the commerce and navigation on the river. Before the river was so completely patrolled as it now is the sinking of steamboats and other river craft, by running on snags, was a common occurrence. During recent years such disasters seldom happen. Although life and property would seem to be much safer now than formerly, the rate of insurance has not materially decreased.

This work during the year was in charge of Maj. C. J. Allen, Corps of Engineers, U. S. A., until January 10, 1896, then temporarily transferred to Lieut. Chester Harding, Corps of Engineers, U. S. A., to January 13, since which date it has been in charge of Maj. Thos. H. Handbury, Corps of Engineers, U. S. A.

It is proposed during the coming fiscal year to continue operating these snag boats as provided for in the river and harbor act of August 11, 1888.

The statistics relating to the commerce benefited by the operations of these snag boats will be found in the report of operations for this year for the improvement of the Mississippi River from the mouth of the Missouri to the mouth of the Ohio River.

Appropriations made by Congress for removing obstructions in Mississippi River.

By act of—		For fiscal year ending—	
March 3, 1879	$100,000.00	June 30, 1890	$49,089.17
June 14, 1880	100,000.00	June 30, 1891	92,720.97
March 3, 1881	80,000.00	June 30, 1892	98,250.00
March 2, 1882	85,000.00	June 30, 1893	96,497.23
July 5, 1884	72,950.63	June 30, 1894	88,252.46
August 5, 1886	56,250.00	June 30, 1895	100,000.00
August 11, 1888	100,000.00	June 30, 1896	80,496.26
Total			1,199,506.72

The headquarters of the snag boats is in St. Louis, which is the nearest port of entry and which is in the collection district of New Orleans.

The amount of customs collected at St. Louis during the fiscal year was $1,129,966.56.

The amount of internal revenue collected was $6,469,443.88.

Money statement.

Amount to be drawn under section 7, act of August 11, 1888	$80,496.26
June 30, 1896, amount expended during fiscal year	80,395.94
June 30, 1896, outstanding liabilities	100.32
July 1, 1896, amount available for fiscal year 1896–1897	100,000.00

TABLE NO. 1.—*Detailed statement of expenditures made in connection with the work of removing obstructions in Mississippi River during the fiscal year 1896, as required by section 7 of the river and harbor act of August 11, 1888.*

Month.	Voucher.	To whom paid.	For what paid.	Amount.
1895				
July...	6	Chester Harding, first lieutenant, Corps of Engineers, U. S. A.	Mileage	$20.68
	8	Chas. J. Allen, major, Corps of Engineers, U. S. A.	do	20.60
	15	Western Union Telegraph Co	Telegrams	1.32
	149	Sundry persons	Pay roll	453.00
Aug...	20	Chas. J. Allen, major, Corps of Engineers, U. S. A.	Mileage	20.60
	21	Chester Harding, first lieutenant, Corps of Engineers, U. S. A.	do	20.60
	32	Sundry persons	Pay roll	1,683.00
	33	do	do	193.00
	34	do	do	770.00
	81	Chester Harding, first lieutenant, Corps of Engineers, U. S. A.	Mileage	20.42
	94	Western Union Telegraph Co	Telegrams	.80
	144	Branch-Crookes Saw Co	Saws	52.00
	146	Andrew F. Koettker	Subsistence	56.44
	148	Anton Lutz	do	21.62
	150	H. Senne	Ice	10.80
	152	F. J. Wehrfritz	Subsistence	63.77
	158	Sundry persons	Pay roll	400.00
	159	do	do	750.00
	160	do	do	1,802.00
	161	do	do	368.00
	162	Natchez Ice Co	Ice, etc	22.30
	164	C. Weir	Subsistence	39.53
	168	Trebus & Steiner	Pads and stamps	.45
Sept...	49	H. L. Fox & Co	Supplies	100.86
	99	Chester Harding, first lieutenant, Corps of Engineers, U. S. A.	Mileage	20.51
	148	Anchor Line Store	Rope and supplies	148.56
	149	Henry Bruck	Subsistence	24.57
	150	Bauer Grocer Co	do	26.43
	152	Gust. Bischoff	do	120.40
	153	Bodenheimer, Landau & Co	do	15.98
	154	M. M. Buck Manufacturing Co	Lanterns, wrenches, etc	25.36
	155	Chas. W. Barstow	Asphaltum, etc	11.85
	156	James Beakey Stove Co	Tinware	7.86
	158	Saml. Cupples Woodenware Co	Brushes, mops, etc	7.42
	159	Cairo City Coal Co	Coal	118.80
	160	Cahill, Swift & Co	Valves, etc	20.82
	161	M. Dougherty	Subsistence	172.60
	162	Goddard Peck Grocery Co	do	7.65
	164	Huse & Loomis Ice and Transportation Co.	Ice	22.69
	165	Jacob Kaiser & Co	Mattresses	18.75
	166	The Knapp-Stout & Co	Lumber	63.35
	167	Kupferle Bros. Manufacturing Co	Valves	3.12
	168	Chas. Kney	Subsistence	26.74
	169	Leonard & Ellis	Oil	16.40
	170	G. E. Meissner	Subsistence	16.57
	171	David Nicholson	do	91.04
	172	N. O. Nelson Manufacturing Co	Brass unions	4.18
	174	National Lead Co	White lead, etc	25.70
	175	Platt & Thornburgh Paint and Glass Co.	Glue	.60
	176	Peatross, Cameron & Co	Coal	175.00
	177	Pittsburg Coal Co	Coal	230.00
	178	Robidoux & Corby	Shovels and supplies	32.51
	179	Thos. Sexton & Co	Kitchen ware	34.11
	180	Simmons Hardware Co	Tools, supplies, etc	25.55
	181	Sligo Iron Store	Iron	10.30
	182	J. D. Streett & Co	Oils, etc	99.68
	184	Jas. A. Tappan	Coal	60.00
	185	Whitelaw Bros	Supplies	28.45
	186	Ward Bros. Produce Co	Subsistence	26.30
	187	Western Anthracite Coal Co	Coal	10.20
	188	Geo. Wenger Machinery and Supply Manufacturing Co.	Cast-iron shoe	4.50
	189	Jos. F. Wangler Boiler and Sheet Iron Works Co.	Cylinders, flanges	54.87
	199	Eagle Packet Co	Freight charges	7.00
	200	Matt Monaghan & Co	Subsistence	49.08
	201	Paddock-Hawley Iron Co	Angle iron	.87
	202	Wrought Iron Range Co	Range grate	3.00
	203	Western Union Telegraph Co	Telegrams	1.23
	275	Buxton & Skinner Stationery Co	Stationery	3.49
	293	Anchor Line Store	Rope, etc	99.87
	294	D. Crawford & Co	Aprons, etc	6.45

TABLE NO. 1.—*Detailed statement of expenditures made in connection with the work of removing obstructions in Mississippi River, etc.*—Continued.

Month.	Voucher.	To whom paid.	For what paid.	Amount.
1895				
Sept...	295	Cairo City Coal Co	Coal	$182.00
	296	Crown Coal and Tow Co	do	217.50
	297	Excelsior Manufacturing Co	Castings	5.90
	298	Jno. Gorman & Bro	Vegetables	11.41
	299	Anton Lutz	Subsistence	27.16
	300	Meyer Bros. Drug Co	Medicines	22.58
	302	Missouri Car and Foundry Co	Lumber	57.51
	303	Pittsburg Coal Co	Coal	360.00
	304	Sligo Iron Store Co	Iron	10.86
	305	H. Senne	Ice	9.24
	306	Jas. A. Tappan	Coal	240.00
	307	G. D. Williamson	Subsistence	22.34
	308	F. J. Wehrfritz	do	64.77
	321	Andrew F. Koettker	do	17.15
	322	John Lowell	do	76.76
	327	Sundry persons	Pay roll	353.00
	328	do	do	772.50
	329	do	do	1,796.00
	330	do	do	356.00
	331	Chas. J. Allen, major, Corps of Engineers, U. S. A.	Mileage	10.30
	332	Chester Harding, first lieutenant, Corps of Engineers, U. S. A.	do	20.60
	336	New York Belting and Packing Co	Hose, packing, etc	60.50
Oct....	33	Chester Harding, first lieutenant, Corps of Engineers, U. S. A.	Mileage	20.60
	44	Eau Claire-St. Louis Lumber Co	Lumber	5.50
	53	Evander Williams	Subsistence	68.13
	54	Berton & Werner	do	16.30
	55	Carl Setz	do	3.25
	56	Wm. Jessop & Sons	Rivets	24.31
	57	Matt Monaghan & Co	Subsistence	127.37
	58	Joseph Hirsch	do	30.03
	59	Loyd G. Harris Manufacturing Co	Lumber	16.44
	64	H. L. Fox & Co	Brushes, etc	13.67
	114	Missouri Car and Foundry Co	Flange	40.28
	120	National Lead Co	White and red lead	42.52
	121	Paddock-Hawley Iron Co	Iron	9.02
	122	J. D. Streett & Co	Linseed oil, etc	18.65
	168	Chester Harding, first lieutenant, Corps of Engineers, U. S. A.	Mileage	20.60
	262	Keuffle & Esser Co	Blue prints, etc	3.13
	276	A. S. Aloe Co	Barometer	20.00
	277	Anchor Line Store	Subsistence	57.95
	278	Berton & Werner	do	22.45
	279	Bauer Grocer Co	do	116.93
	280	Alois Boschert & Co	do	33.54
	281	George Boschert	do	70.12
	282	The Consolidated Coal Co. of St. Louis	Coal	246.75
	283	Cairo City Coal Co	do	90.10
	284	Desnoyers Shoe Co	Rubber boots	10.80
	285	Day Rubber Co	Packing	1.13
	286	M. Dougherty	Subsistence	209.08
	287	Fischer Packing Co	do	87.75
	288	L. S. Koerber	do	13.39
	289	Anton Lutz	do	20.31
	290	David Nicholson	do	71.27
	291	Natchez Ice Co	Ice, etc	28.80
	292	Matt Monaghan & Co	Subsistence	63.34
	293	O'Connor Furnace and Range Co	Repair of stove	9.00
	294	Paddock-Hawley Iron Co	Sheet iron	1.01
	295	Pittsburg Coal Co	Coal	371.32
	296	Peatross, Cameron & Co	do	236.25
	297	Robidoux & Corby	Gas pipe	3.55
	298	H. Senne	Ice	8.63
	299	Simmons Hardware Co	Clothes wringer	2.00
	300	Thos. Sexton & Co	Stove pipes, etc	77.44
	301	Jas. A. Tappan	Coal	120.00
	302	A. Weir Produce Co	Subsistence	46.35
	303	David Nicholson	do	46.16
	304	F. J. Wehrfritz	do	44.85
	332	Sundry persons	Pay roll	300.00
	333	Con. P. Curran Printing Co	Job printing	2.25
Nov.	1	Sundry persons	Pay roll	885.00
	2	do	do	1,830.00
	3	do	do	347.00
	65	Chester Harding, first lieutenant, Corps of Engineers, U. S. A.	Mileage	10.68
	66	Northwestern Stove Repair Co	Stoves	65.00

TABLE NO. 1.—*Detailed statement of expenditures made in connection with the work of removing obstructions in Mississippi River, etc.*—Continued.

Month.	Voucher.	To whom paid.	For what paid.	Amount.
1895				
Nov...	141	Cairo City Coal Co	Coal	$146.00
	142	A. A. Ehrman	Subsistence	34.91
	143	Kupferle Bros. Manufacturing Co	Barrel for steam whistle	6.50
	144	L. S. Koerber	Subsistence	54.40
	145	Anton Lutz	do	34.73
	146	Matt Monaghan & Co	do	63.08
	147	G. J. Murphy & Co	Coal	40.54
	148	W. H. Pritchartt & Co	Subsistence	18.20
	149	Peatross, Cameron & Co	Coal	259.37
	150	Pittsburg Coal Co	do	547.18
	151	Sylvester Coal Co	do	29.43
	152	H. Senne	Ice	3.57
	153	Jas. A. Tappan	Coal	60.00
	154	Evander Williams & Co	Subsistence	94.04
	155	Western Electrical Supply Co	Globes	8.00
	156	F. J. Wehrfritz	Subsistence	57.33
	157	Greenville Produce and Poultry Co	do	17.42
	270	Sundry persons	Pay roll	353.00
Dec....	5	Sundry persons	Pay roll	995.17
	6	do	do	1,797.00
	7	do	do	366.00
	72	Chester Harding, first lieutenant, Corps of Engineers, U. S. A.	Mileage	20.51
	78	Postal Telegraph Cable Co	Telegram	.27
	79	Iowa Iron Works ($22,817.22*)	Repairs	5,142.19
	80	Paddock-Hawley Iron Co	Wire	1.12
	81	Bauer Grocer Co	Subsistence	116.59
	82	Brockman & Trauernicht	do	87.18
	83	W. H. Caffrey & Co	Soap, etc	35.70
	84	John T. Guyre	Services as diver	60.00
	85	Gerritzen Bros. & Co	Log book	3.00
	86	Longmeyer & Rutledge	Coal	157.00
	87	Anton Lutz	Subsistence	49.13
	88	Matt Monaghan & Co	do	126.12
	89	G. J. Murphy & Co	Coal	113.28
	90	G. F. Meyer & Co	Oil	42.86
	91	Shanks, Pillips & Co	Dynamite, etc	30.75
	92	J. D. Streett & Co	Oil	5.46
	93	Geo. T. Sams & Co	Subsistence	50.81
	94	Jas. A. Tappan	Coal	160.00
	95	F. J. Wehrfritz	Subsistence, etc	117.65
	96	Evander Williams & Co	do	83.99
	97	Waters Pierce Oil Co	Turpentine	9.47
	98	Pittsburg Coal Co	Coal	390.00
	99	Cairo City Coal Co	do	243.60
	152	Chas. J. Allen, major, Corps of Engineers, U. S. A.	Mileage	20.60
	153	G. D. Williamson, Jno. A. Haynes, proprietor.	Subsistence	56.69
	162	Ewald Iron Co	Iron, etc	12.06
	163	Horn & Co	Subsistence	29.89
	164	Geo. J. Fritz Foundry and Machine Co	Castings	19.77
	165	Schaeffer Bros. & Powell Manufacturing Co.	Candles	3.90
	166	Iowa Iron Works	Repairs	691.90
	182	Sundry persons	Pay roll	300.00
	187	Leonard & Ellis	Oil	26.25
	188	American Express Co	Express charges	.70
1896				
Jan....	6	Sundry persons	Pay roll	1,041.50
	7	do	do	486.88
	8	do	do	1,840.00
	9	do	do	305.00
	25	St. Louis and New Orleans Anchor Line	Freight charges	1.75
	26	Western Brass Manufacturing Co	Brass unions	11.48
	1	Mississippi Valley Marine Railway and Dock Co.	Lumber	110.33
	2	Cairo City Coal Co	Coal	304.80
	3	F. J. Wehrfritz	Subsistence	125.73
	4	David Nicholson	do	44.47
	5	M. Dougherty	do	344.72
	6	Anton Lutz	do	86.19
	7	Paddock-Hawley Iron Co	Iron and rivets	20.13
	8	Bauer Grocer Co	Subsistence	98.42
	9	Chas. W. Barstow	Candles, etc	6.00
	10	Daniel Hartman	Dishes, etc	11.90
	11	Matt Monaghan & Co	Subsistence	252.94

*$17,675.03 accounted for as outstanding liabilities June 30, 1895.

TABLE NO. 1.—*Detailed statement of expenditures made in connection with the work of removing obstructions in Mississippi River, etc.*—Continued.

Month.	Voucher.	To whom paid.	For what paid.	Amount.
1896				
Jan....	12	G. D. Williamson, John A. Haynes, proprietor.	Subsistence.....	$73.96
	13	A. M. Nelson Paint Co.....	White lead, etc	38.95
	14	J. D. Streett & Co.....	Oil and paint	51.81
	15	Chas. Kney.....	Subsistence	45.37
	16	Geo. T. Sams & Co	.....do	55.04
	17	Jas. A. Tappan & Co	Coal	160.00
	18	Pittsburg Coal Co	.....do	1,105.45
	19	H. C. Coffin & Co.....	Supplies	14.35
	20	Bodenheimer, Landau & Co.....	Subsistence.....	116.13
	21	Western Union Telegraph Co.....	Telegrams.....	18.07
	22	L. S. Koerber.....	Subsistence.....	59.60
	23	Broderick & Bascom Rope Co	Tarred marline, etc.....	14.92
	24	G. J. Murphy & Co.....	Coal	9.30
	25	E. E. Souther Iron Co.....	Angle irons.....	12.80
	26	G. D. Williamson, Jno. A. Haynes, proprietor.	Supplies.....	31.83
	27	L. M. Rumsey Manufacturing Co	.....do	19.00
	28	H. Senne.....	Cartage.....	34.60
	29	Ewald Iron Co.....	Iron and steel.....	30.62
	30	Simmons Hardware Co	Supplies	10.72
	31	Schuh Drug Co.....	Brushes, etc	43.21
	32	Day Rubber Co.....	Rubber boots, etc.....	22.02
	33	Thos. Sexton & Co	Supplies	24.15
	34	Peatross, Cameron & Co.....	Coal	212.45
	35	Horn & Co.....	Subsistence.....	24.15
	36	Wood & Bennett.....	.....do	98.56
	37	Evander Williams & Co	Supplies	107.29
	38	Leonard & Ellis.....	Oil.....	5.00
	39	Sundry persons.....	Pay roll	553.00
	40	.....do	.....do	1,777.50
	41	.....do	.....do	397,50
	42	Cairo City Coal Co.....	Coal	173.60
	43	Valentine Resch.....	Supplies	16.65
	44	Bodenheimer, Landau & Co	.....do	20.75
	45	Woodward Iron and Hardware Co.....	Tools and supplies.....	21.10
	46	Loyd G. Harris Manufacturing Co	Freight charges	2.50
	47	The Halliday Phillips Wharf Boat Co....	Storage.....	4.20
	48	Crane Company	Steam fittings	7.14
	49	Lee Brothers.....	Supplies	89.47
	50	Geo. T. Sams & Co	.....do	64.24
Feb....	1	Sundry persons	Pay roll	1,015.00
	2	.....do	.....do	1,175,00
	3	Geo. Boschert	Supplies	26.08
	4	Fischer Packing Co	.....do	44.85
	5	Valentin Resch.....	.....do	21.79
	6	Geo. T. Sams & Co.....	.....do	26.96
	7	Crown Coal and Tow Co.....	Coal	120.80
	8	Arrow Boiler Compound Co.....	Boiler compound	31.80
	9	M. M. Buck Manufacturing Co.....	Glass	3.00
	10	Crown Coal and Tow Co.....	Coal	105.00
	11	Big Muddy Coal and Iron Co.....	.....do	66.25
	12	Western Iron and Supply Co.....	Valves.....	9.60
	13	Woodward Iron and Hardware Co.....	Copper	2.40
	14	Western Union Telegraph Co	Telegrams	4.09
	15	Anchor Line Store.....	Brushes, etc	58.43
	16	.....do	Supplies	16.90
	17	.....do	.....do	17.51
	18	J. H. Coffin & Co.....	.....do	428.37
	19	Matt Monaghan	.....do	185.74
	20	Pittsburg Coal Co	Coal	945.00
	21	Bentzen Commission Co	Supplies.....	24.03
	22	Galloway Coal Co.....	Coal	7.80
	23	Jas. A. Tappan.....	.....do	256.30
	24	Chas. Kney	Supplies.....	93.02
	25	The Oliver-Finnie Grocer Co.....	.....do	323.95
	26	Big Muddy Coal and Iron Co.....	Coal	30.00
	27	Western Anthracite Coal Co.....	.....do	62.20
	28	Horn & Co.....	Supplies.....	34.35
	29	L. S. Koerber.....	.....do	54.04
	30	Meyer Bros. Drug Co	.....do	12.07
	31	Chickasaw Iron Works.....	.....do	6.00
	32	H. L. Ettman & Co	Sponges	8.50
	33	G. D. Williamson.....	Supplies.....	6.70
	34	Geo. T. Sams & Co	.....do	33.78
	35	Valentine Resch	.....do	8.65
	36	Pittsburg Coal Co.....	Coal	315.00
	37	The Oliver-Finnie Grocer Co.....	Supplies.....	65.45
	38	Matt Monaghan & Co.....	.....do	40.74

TABLE NO. 1.—*Detailed statement of expenditures made in connection with the work of removing obstructions in Mississippi River, etc.*—Continued.

Month.	Voucher.	To whom paid.	For what paid.	Amount.
1896				
Feb....	39	Chas. Kney	Supplies	$42.57
	40	Sundry persons	Pay roll	300.00
	41	Anchor Line Store	Supplies	34.22
	42	Cairo City Coal Co	Coal	76.00
	43	M. Dougherty	Supplies	127.30
	44	L. S. Koerber	.....do	69.92
	45	Paddock-Hawley Iron Co	.....do	27.38
	46	C. Pichetto	.....do	15.72
	47	Simmons Hardware Co	Screw plate	4.07
	48	Sundry persons	Pay roll	1,840.00
	49	.....do	.....do	330.00
	50	.....do	.....do	282.00
	51	.....do	.....do	1,860.00
	52	Arrow Boiler Compound Co	Boiler compound	31.80
Mar ...	1	Big Muddy Coal and Iron Co	Coal	67.50
	2	Cairo City Coal Co	.....do	51.20
	3	J. H. Coffin & Co	Supplies	22.90
	4	Chas. Kney	.....do	36.86
	5	Lee Brothers	.....do	9.88
	6	Matt Monaghan & Co	.....do	104.43
	7	Pittsburg Coal Co	.....do	603.75
	8	Valentine Resch	.....do	23.14
	9	Sanders Duck and Rubber Co	Rubber boots	10.20
	10	Siemens & Halske Electric Co. of America	Voltmeter	26.42
	11	Jas. A. Tappan	Coal	140.00
	12	E. H. Warren & Son	Lumber	36.10
	13	G. D. Williamson	Supplies	6.96
	14	Chickasaw Iron Works	Castings	20.07
	15	Horn & Co	Supplies	49.49
	16	Peatross, Cameron & Co	Coal	197.75
	17	Geo. T. Sams & Co	Supplies	55.73
	18	Western Union Telegraph Co	Telegrams	2.00
	19	G. W. Pauley	Services	23.00
	20	Chester Harding, first lieutenant Corps of Engineers, U. S. A.	Mileage	43.28
	21	Bentzen Commission Co	Supplies	18.26
	22	H. A. Carroll & Co	.....do	6.32
	23	George Boschert	.....do	15.59
	24	M. M. Buck Manufacturing Co	.....do	7.39
	25	Eagle Boat Store Co	.....do	49.55
	26	Fischer Packing Co	.....do	40.41
	27	Western Anthracite Coal Co	Coal	7.70
	28	Simmons Hardware Co	Supplies	9.80
	29	Big Muddy Coal and Iron Co	Coal	90.00
	30	Crown Coal and Tow Co	.....do	105.00
	31	Sundry persons	Pay roll	353 00
	32	Bentzen Commission Co	Supplies	24.62
	33	Chas. Kney	.....do	142.47
	34	L. S. Koerber	.....do	57.27
	35	Matt Monaghan & Co	.....do	234.84
	36	O'Connor Furnance and Range Co	.....do	1.60
	37	Consolidated Coal Co. of St. Louis	Coal	92.63
	38	Peatross, Cameron & Co	.....do	166.25
	39	Pittsburg Coal Co	.....do	910.00
	40	Jas. A. Tappan	.....do	420 00
	41	Sundry persons	Pay roll	1,850.00
	42	.....do	.....do	303.33
	43	Arrow Boiler Compound Co	Boiler compound	35.75
	44	Sundry persons	Pay roll	1,804.00
	45	.....do	.....do	270.00
	46	C. C. Huthmacher	Subsistence	2.50
	47	Western Electrical Supply Co	Carbons	12.50
Apr ...	1	Horn & Co	Supplies	12.55
	2	Fischer Packing Co	.....do	34.68
	3	George Boschert	.....do	47.14
	4	Big Muddy Coal and Iron Co	Coal	157.50
	5	The Consolidated Coal Co. of St. Louis	.....do	52.00
	6	The Cairo City Coal Co	.....do	104.40
	7	Fisher Packing Co	Supplies	25.70
	8	Valentine Resch	.....do	17.44
	9	Geo. T. Sams & Co	.....do	34.14
	10	Robt. D. Patterson Stationery Co	.....do	43.98
	11	Fairbanks Morse & Co	Repairs	645
	12	John Lowell	Ice	15 75
	13	Andrew J. Morse & Son	Diving outfit	724.00
	14	Trebus and Steiner	Stamps	4.65
	15	Benson Commission Co	Supplies	12.83
	16	The Ætna Powder Co	.....do	60.54
	17	Chas. W. Barstow	.....do	156.60

TABLE NO. 1.—*Detailed statement of expenditures made in connection with the work of removing obstructions in Mississippi River, etc.*—Continued.

Month.	Voucher.	To whom paid.	For what paid.	Amount.
1896				
Apr ...	18	Big Muddy Coal and Iron Co	Coal	$157.50
	19	Cairo City Coal Co	....do	48.00
	20	J. H. Coffin & Co	Rope	144.90
	21	Mitchell Clay Manufacturing Co	Supplies	10.75
	22	David Nicholson	....do	324.22
	23	Page & Tolkacz	Ventilator	5.50
	24	L. M. Rumsey Manufacturing Co	Supplies	6.97
	25	John Rohan & Son Boiler Works Co	Repairs	100.00
	26	Valentine Resch	Supplies	9.70
	27	Shultz Belting Co	Pulley cover	4.38
	28	Whitelaw Bros	Supplies	55.00
	29	Western Union Telegraph Co	Telegrams	1.80
	30	John J. Ganahl Lumber Co	Lumber	121.26
	31	J. D. Streett & Co	Supplies	124.10
	32	Whitelaw Bros	....do	90.00
	33	Sundry persons	Pay roll	300.00
	34	....do	....do	1,014.50
	35	....do	....do	494.50
	36	....do	....do	1,572.50
	37	....do	....do	174.00
	38	G. H. Miller	Services	29.17
	39	M. Dougherty	Supplies	135.27
	40	Peter Paulson	Services	26.00
May ...	1	J. W. Matheis	Eggs	7.75
	2	Oscar Setz	Milk	6.00
	3	The Consolidated Coal Co. of St. Louis	Coal	169.00
	4	T. Bradley	Traveling expenses	4.40
	5	Anchor Line Store	Supplies	22.43
	6	F. Bocler	Sectional covering	501.89
	7	M. M. Buck Manufacturing Co	Supplies	44.12
	8	....do	....do	36.98
	9	Adolph J. Bentzen	....do	160.38
	10	Fischer Packing Co	....do	199.91
	11	T. Bradley	Services	22.50
	12	Huse & Loomis Ice and Transportion Co.	Ice	10.50
	13	C. F. Liebke Hardwood Mill and Lumber Co.	Lumber	257.96
	14	Paddock-Hawley Iron Co	Supplies	9.80
	15	Page & Tolkacz	....do	28.55
	16	L. M. Rumsey Manufacturing Co	....do	22.58
	17	Geo. Wenger Machinery and Supplies Manufacturing Co.	....do	10.29
	18	Wm. C. Stevens	Traveling expenses	1.80
	19	Western Union Telegraph Co	Telegrams	2.13
	20	Missouri Car and Foundry Co	Ice	57.19
	21	R. Bush	Milk	1.80
	22	Geo. J. Fritz Foundry and Machine Co	Supplies	247.24
	23	Wrought Iron Range Co	....do	10.00
	24	Sundry persons	Pay roll	500.00
	25	....do	....do	1,262.50
	26	....do	....do	1,434.00
June...	1	R. Bush	Supplies	5.58
	2	....do	....do	12.40
	3	Howard Ewald & Co	....do	131.10
	4	G. E. Meissner	....do	7.70
	5	J. W. Mathies	....do	19.20
	6	M. M. Buck Manufacturing Co	Cotton batting	7.25
	7	Adolph J. Bentzen	Supplies	125.66
	8	Fischer Packing Co	....do	142.79
	9	Paddock-Hawley Iron Co	....do	67.39
	10	Shultz Belting Co	Repairs	2.85
	11	L. M. Rumsey Manufacturing Co	Supplies	10.19
	12	Paddock-Hawley Iron Co	....do	72.27
	13	A. M. Nelson Paint Co	....do	30.91
	14	Missouri Glass Co	....do	11.19
	15	Monarch Rubber Co	Rubber boots	11.56
	16	Eagle Boat Store Co	Supplies	36.45
	17	M. Dougherty	....do	281.29
	18	Chas. W. Barstow	....do	29.30
	19	Broderick & Bascom Rope Co	Rope	8.52
	20	R. Bush	Supplies	16.73
	21	Arrow Boiler Compound Co	Boiler compound	109.25
	22	Anchor Line Store	Supplies	96.62
	23	Flachman & Matthews	....do	22.50
	24	Waters-Pierce Oil Co	Oil	80.34
	25	R. B. Gray China Co	Tray	1.50
	26	Sligo Iron Store Co	Steel	2.28
	27	Northwestern Stove Repair Co	Supplies	7.55
	28	Bauer Grocery Co	....do	120.04

TABLE NO. 1.—*Detailed statement of expenditures made in connection with the work of removing obstructions in Mississippi River, etc.*—Continued.

Month.	Voucher.	To whom paid.	For what paid.	Amount.
1896				
June ..	29	Wrought Iron Range Co	Supplies	$30.73
	30	Simmons Hardware Co	do	110.06
	31	Sylvester Coal Co	Coal	8.20
	32	Branch-Crookes Saw Co	Saws	90.43
	33	The Knapp-Stout & Co. Company	Lumber	30.33
	34	M. M. Buck Manufacturing Co	Supplies	149.29
	35	Adolph J. Bentzen	do	154.02
	36	Ewald Iron Co	Nuts	3.70
	37	Fischer Packing Co	Supplies	131.87
	38	E. E. Souther Iron Co	do	16.07
	39	Ambler & Materne	do	4.75
	40	H. L. Ettman & Co	Sponges	10.20
	41	N. O. Nelson Manufacturing Co	Ells	.29
	42	Geo. J. Fritz Foundry and Machinery Co.	Sheaves	6.72
	43	Sundry persons	Pay roll	500.00
	44	Richard Garstang	Smokestack	285.00
	45	Huse & Loomis Ice and Transportation Co.	Ice	162.30
	46	Sundry persons	Pay roll	1,458.00
	47	do	do	1,240.00
	48	Platt & Thornburgh Paint and Glass Co.	Supplies	13.88
	49	J. D. Streett & Co	do	63.00
	50	R. E. Birch	Traveling expenses	4.40
	51	Edward Culver	do	20.00
	52	Anchor Line Store	Rope	153.44
	53	M. M. Buck Manufacturing Co	Rivets	.29
	54	Flachman & Matthews	Tallow	3.50
	55	St. Louis Iron and Machine Works	Castings	18.59
	56	Leonard & Ellis	Oil	5.00
				80,395.94
		Total of outstanding liabilities June 30, 1896:		
		Purina Manufacturing Co	Filter	20.00
		Revere Rubber Co	Supplies	12.30
		Berry Bros., Limited	do	18.50
		Scruggs, Vandervoort & Barney	do	49.52
		Total outstanding		100.32
		Total expended and outstanding		80,496.26

TABLE NO. 2.—*Summary of expenses for operating U. S. snag boats H. G. Wright and J. N. Macomb, in connection with the work of removing obstructions in Mississippi River during fiscal year ending June 30, 1896.*

Application.	1895.					
	July.	August.	September.	October.	November.	December.
Office expenses	$454.32	$401.25	$354.23	$305.38	$353.00	$300.27
Supervision	41.28	61.62	51.41	41.20	10.68	41.11
Expenses of snag boat H. G. Wright:						
Crew	.....	1,520.00	772.50	.....	885.00	995.17
Outfit	.....	.....	.....	.....	.....	.....
Fuel	.....	.....	.....	.....	30.54	113.28
Subsistence	.....	96.19	101.17	145.06	95.63	166.78
Supplies	.....	.....	.....	.....	.....	42.86
Repairs	.....	.....	20.82	.....	.....	5,834.09
Miscellaneous	.....	.....	.....	.....	.....	3.70
Expenses of snag boat J. N. Macomb:						
Crew	.....	4,046.00	2,152.00	.....	2,177.00	2,163.00
Outfit	.....	52.00	307.61	34.47	.....	.....
Fuel	.....	.....	1,593.50	1,064.42	1,041.98	950.60
Subsistence	.....	118.27	727.71	1,031.95	282.05	551.27
Supplies	.....	.....	462.87	99.56	.....	112.65
Repairs	.....	.....	218.46	170.28	79.50	31.83
Miscellaneous	.....	.....	33.07	.....	.....	60.00
Total	495.60	6,295.33	6,795.35	2,892.32	4,965.38	11,366.61

TABLE NO. 2.—*Summary of expenses for operating U. S. snag boats H. G. Wright and J. N. Macomb, etc.*—Continued.

Application.	1896.						
	January.	February.	March.	April.	May.	June.	Total.
Office expenses	$571.07	$304.09	$398.28	$350.43	$503.93	$500.00	$4,796.25
Supervision	.....	.....	.....	.....	.....	.....	247.30
Expenses of snag boat H. G. Wright:							
Crew	1,528.38	4,332.00	2,176.33	1,509.00	1,434.00	1,458.00	16,610.38
Outfit	120.98	23.95	17.51	868.90	26.66	116.94	1,174.94
Fuel	655.70	775.25	729.03	313.90	.....	8.20	2,635.90
Subsistence	915.96	494.17	317.00	322.95	90.70	604.64	3,350.25
Supplies	199.13	127.69	172.95	64.92	120.25	189.08	916.88
Repairs	241.57	9.77	1.60	432.48	977.95	584.94	8,103.22
Miscellaneous	39.80	.....	.....	.....	.....	24.40	67.90
Expenses of snag boat J. N. Macomb:							
Crew	4,320.00	2,170.00	2,074.00	1,801.67	1,285.00	1,240.00	23,428.67
Outfit	11.56	315.27	.....	.....	8.20	378.89	1,108.00
Fuel	1,309.90	1,209.10	2,122.75	205.50	169.00	.....	9,666.75
Subsistence	713.25	776.74	531.92	346.47	95.73	574.94	5,750.30
Supplies	16.21	184.10	.....	.....	160.65	312.19	1,348.23
Repairs	11.48	6.00	20.07	244.15	155.23	252.57	1,189.57
Miscellaneous	4.25	.....	.....	.....	4.40	.....	101.72
Total	10,659.24	10,728.13	8,561.44	6,460.37	5,031.70	*6,244.79	*80,496.26

* Includes $100.32 outstanding liabilities.

W 2.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN OHIO AND MISSOURI RIVERS.

The object of the improvement is to obtain eventually a minimum depth at standard low water of 6 feet from the mouth of the Missouri River to St. Louis, a distance of 16 miles, and of 8 feet at the same stage of water from St. Louis to the mouth of the Ohio River, 178 miles, the natural depth being in many cases from 3½ to 4 feet. The channel is divided at a number of points by islands forming sloughs and secondary channels behind them, through which a good deal of the volume of the flow is diverted to the detriment of navigation.

The initial point of the work for the lower portion is St. Louis, the programme being to make the work continuous, proceeding downstream from that city.

The first work for improvement began in 1872, and was continued for a number of years as appropriations were made, the works consisting of dikes and dams of brush and stone, erected with a view to confining the low-water volume to one channel, and of revetments to hold and preserve the banks where necessary or advisable.

Under these appropriations work of this character was done at the following localities between the mouth of the Ohio and the mouth of the Illinois River, viz, Piasa Island, Alton Harbor, Sawyer Bend, St. Louis Harbor, Arsenal Island, Horsetail Bar, Carroll Island, Fort Chartres, Turkey Island, Kaskaskia Bend, Liberty Island, Devils Island, and in the vicinity of Cairo, Ill.

The present project is a continuation of the plan adopted in 1881, and contemplates a reduction of the river to an approximate width of 2,500 feet below St. Louis, the natural width being in many cases from 1 to 1½ miles. The method employed is the building up of new banks out to the line desired from the solid matter brought down by the river, and which is collected by means of hurdles. The banks, both new and old, are revetted where necessary. Other means are also used occasionally for completing or hastening the depth required.

A hurdle, as the term is here used, is one of many silt-arresting

devices that have been experimented upon in this country and elsewhere. The hurdle consists, essentially, of a row or of parallel rows of piling, the piles driven either singly or in clumps, the piling being connected lengthwise of the hurdle by wattling of fine brush or by curtains composed of brush and lodged against the upstream side of one of the rows of piles, the whole forming a permeable dike through which the silt-laden current can pass, though with greatly diminished velocity, resulting in deposits of silt above and below the hurdles.

These deposits are generally soon overgrown with willows or cottonwood, and after they arrive at sufficient height they can be revetted on their river fronts.

To guard against loss by scour of the piles, a broad flexible mattress is first sunk on the line of the hurdle. Through this mat the piles and clumps of piles are driven.

During the past year the hurdles have been constructed of clumps of piles, three piles and upward to each clump. These piles are driven so that when their upper ends are drawn together by means of a wire rope they form a sort of pyramidal structure, the horizontal distances of the piles from each other at the surface of the river bed being 8 to 10 feet, depending mainly upon the depth of the water.

The wire ropes are made on the work; they are composed of 14 to 18 strands of No. 14 galvanized iron wire. They are drawn taut by means of the pile-driver machinery. At each turn of the rope around the upper end of the clump of piles a spike is driven as an additional guard against the rope slipping, though the wire itself generally binds or cuts into the piling sufficiently to prevent any slip. This method of drawing the upper ends of the piles together appears to be better than the old one of bolting them.

The tops of the piles are generally at an elevation of 20 feet above extreme low water, excepting that in the curtain or wattling row the top of one pile of the clump is at an elevation of about 25 feet above that stage in order to intercept drift at high stages and prevent it from crossing the line of hurdle and dragging the top of the latter with it.

The curtain or wattled row is braced by vertical diagonal braces heeled against a row of clumps spaced at such distances below as to make the angle of the braces about 45°.

The heel of the brace is held by a clevis passing around one of the piles of the lower clump, with its pin through the brace. At top the brace is bolted to one or more of the piles in the upper clump.

The piling of the hurdle row is so spaced as to represent an equivalent of one pile to the linear foot of hurdle. The piles are driven by means of the hydraulic jet as well as by the hammer, the latter weighing 2,400 pounds, and sometimes by both combined.

The completed curtain, or the wattling, whichever may be used, is generally carried finally to a height of 20 feet above extreme low water. The mattress is from 60 to 135 feet in width, depending upon the depth of water and consequent length of piles, as well as upon liability of the bed to suffer from scour. It is fabricated upon floating ways, in place, by wattling brush upon poles spaced about 5 feet apart and in any length desired. Continuity is obtained by lapping the poles and fastening them together with spikes and wire. When additional strength is required wire cables are used across and in the direction of the length of the mattress. The brush is spiked to the poles at the edges of the mattress and at other points, about one spike to every third pole. In sinking the mat a little less than 1 cubic yard of broken rock is required to a cord of brush.

The piles used in the hurdles run in lengths from 25 to 60 feet, and

their average penetration in the bottom is about 15 feet. They are driven with the large end down.

At the shore end of the hurdle the bank is revetted for about 300 feet, of which 200 feet is below the axis of the hurdle.

In constructing the shore revetment a mat about 120 feet or more in width, its inner edge at the surface of standard low water, is sunk. The bank is then eventually graded to a slope of one-half and covered with riprap. Where necessary to grade the bank by artificial means the grading is done by the hydraulic method or by means of shovels, etc.

Since the adoption of this project work has been done at the following localities by methods substantially as above described, viz: Piasa Island, Alton Harbor, St. Louis Harbor, Cahokia Chute, Arsenal Island, Horsetail Bar, Carroll Island, Twin Hollows, Pulltight and Beards Island, Chesley Island, Jim Smiths, Sulphur Springs, Foster Island, Lucas, Cornice Island, Calico Island, Michaels Landing, Rush Tower, Fort Chartres, Crooks Landing, Turkey Island, Ste. Genevieve, Liberty Island, Minton Point, and Cape Girardeau and vicinity of Cairo.

At the beginning of the fiscal year work was in active progress in the field in the following localities: Twin Hollows, Sulphur Springs, Lucas, Cornice Island, Michaels Landing, Turkey Island, Ste. Genevieve, and Liberty Island. The work was being done by day labor, and the material procured partly by day labor and partly by contract. The towing was done by towboats belonging to the Government.

The following is a brief summary of the work done during the year in the various localities in their order from St. Louis down. The distances are measured from the south limit of St. Louis, which is 8 miles below the bridge.

For a clear understanding of the situation reference is invited to the accompanying map of the reach of the river covered by the work.

Horsetail Bar.—This reach comprises that portion of the river lying between the River Des Peres and the foot of Carroll Island. It is about 3 miles in length.

Work in this locality was commenced October 21 and discontinued November 14. In this time the bank upon the west side was revetted for a distance of 1,500 feet from the standard low-water line to about 14 feet above.

Before the improvement of the river was commenced this was probably the worst locality during low water to be found below St. Louis. At these stages 3½ and 4 feet were frequently the best water that could be found. It is now so far improved that it is omitted from the localities at which soundings are taken by steamboat men.

Twin Hollows (6 miles below St. Louis).—At this locality two sections of mattress for protection of the bank below standard low water, aggregating 2,120 feet, were put in place and the bank above them partly revetted. This work was commenced July 5 and suspended for the season August 2.

Sulphur Springs.—This locality commences about 13 miles below St. Louis and extends down 4 miles.

The work done here during the season consisted in extending and strengthening hurdle lines and protecting their inshore ends with bank revetment.

Work has been necessarily slow at this point on account of having to gradually crowd the steamboat channel to the westward and at the same time not interfere with navigation.

The work of the season was commenced July 15, suspended July 28, resumed October 4, and suspended November 19.

There were 2,350 feet of hurdle work done and 10,580 square feet of revetment at ends of hurdles put in place; 2,239 piles were driven.

Foster Island (17½ miles below St. Louis).—In this locality the work consisted in carrying the protection of the west side of Foster Island up to about 11 feet above standard low water for a distance of 800 feet.

The work was commenced October 22 and suspended November 2.

Lucas.—This locality extends from the foot of Foster Island, 20 miles below St. Louis, downstream about 3 miles to Cornice Island.

The work consisted in building a number of short hurdles to reestablish in efficiency the series formerly built here and new lines of hurdles to extend the work downstream. Considerable work was done in strengthening the upper hurdles of the series where the water was deep and the trend of the channel decidedly toward shore.

Work was continued in this locality until October 19, resumed November 14, and continued until November 24, the close of the season. It was again resumed March 14, 1896, and suspended for a more favorable stage of water April 11, when the working party was transferred down the river to Liberty Reach.

The work done here during the season is represented by 9,420 feet of hurdle constructed, 312,981 square feet revetment at ends of hurdles, and a large amount of other work pertaining to them; 7,825 piles were driven.

Cornice Island (23 miles below St. Louis).—The work in this locality was the completion of the series of five hurdles begun during the preceding year. The work was in progress at the beginning of the year and closed August 6. During the season 495 feet of hurdle was constructed and 1,965 feet strengthened; 1,910 linear feet of curtain was made; 7,170 square yards of bank revetment was placed at the ends of the hurdles, and other work done. This work was finished August 6 as far as the stage of the river would admit.

Michaels Landing (27 miles below St. Louis).—At this point commences a series of work extending down the river about 9 miles, covering what is known as the Rush Tower Reach. The principal work done during the year consisted in repairs, extensions, and completion to hurdles previously commenced, and in bank protection. In the extension of one of the principal upper hurdles it was deflected downstream and connected with the upper end of a towhead, which was substantially revetted. A considerable current was thrown against this hurdle, to resist which the hurdle was made proportionately strong. The foundation mattress was increased in width to 130 feet. The length of hurdle built was 1,750 feet. Piles were placed in clumps of 3 and 4 each, 8 feet apart, and curtained to a height of 20 feet. The shore connections of the hurdles were strengthened, and the ice buttresses were raised and strengthened with stone. Heavy mattresses were made and sunk over the drift that had collected along the upper side of this hurdle. The following are items of principal work done in this locality: Piles driven, 1,025; foundation mat made and placed, 2,650 linear feet; curtains made, 2,500 linear feet; drift mat made, 3,502 linear feet.

At Danby Landing, in this locality, the project contemplated the revetment of the Missouri shore wherever the bank was eroded to the proposed shore line. The position of the bank having reached that line, the revetment of the shore between this point and the head of the Chute between Ames and Lee islands was begun September 18. A section 4,750 feet long was revetted by placing a mattress below low water and carrying the revetment about 15 feet above that line. The work was discontinued November 15.

Fort Chartres.—This is a reach of the river commencing near Brickeys Mill, 38 miles below St. Louis, and extending downstream 8 miles to the foot of Turkey Island.

At Bruce Island, in this locality, some bank-revetment work was done during the first two weeks in November. The revetment was raised from the 6-foot contour, at which it had been left in the fall of 1894, to the 12-foot contour, to which the bank had been graded by the action of the high water of July, 1895. This bank for the entire length, 3,350 feet, that had received its low-water protection in 1894, was completed.

At Crooks Landing the work of the year consisted in the construction of hurdles, which had been delayed on account of changes in the channel in the vicinity. On account of the abnormally low water during the fall of 1895, parts of the hurdles of this series could not be built. The river ends of some rested during this working season upon bars inaccessible to the pile drivers and other plant used in their construction. The head of the series was reenforced by building two strong lines furnished with buttresses and heavy revetments. The hurdles of this series were built with foundation mattresses 100 feet in width, through which the piles were driven in double tiers of 4-pile clumps, curtained to the 15-foot stage of water, but different from the usual form in that the tops of the piles sloped from the 25 to the 15 foot stage of water upon the outer 500 feet of the ends of the hurdles, with the view to facilitating the passage of drift and ice over them.

The work was discontinued October 19. It is represented by 2,964 piles driven; 3,910 linear feet foundation mattress sunk; 2,760 linear feet curtain work; 688 linear feet drift-mat made; 8,300 square feet stone revetment in place, and 2 ice buttresses constructed.

Turkey Island.—Work was in progress at this point at the beginning of the year, continued through July, suspended and resumed again about the middle of October, and discontinued November 21. It consisted in revetting the west face of the island. A low-water protection was given to this for a distance of 5,250; and the revetment extended up the bank to a 15-foot stage on the upper 2,500, and to the 8-foot stage for the next 750 feet, and to the 5-foot stage on the lower 2,000 feet.

Ste. Genevieve.—The reach of the river under improvement in this locality extends from Little Rock, Mo., 47 miles below St. Louis, to near the mouth of the Kaskaskia River, 7 miles below.

This has always been a reach of wide river over which low-water navigation was difficult on account of the variable and uncontrolled position of the channel. The improvement in progress consists in the construction of a series of hurdles extending out from the Illinois and Missouri shores. The work was commenced in 1891, when three hurdles were built upon the Illinois side.

During the last year these were repaired and ten additional ones constructed on the same side of the river. On the Missouri side six hurdles were completed and five partially so, making a total of about 23,500 feet. There were about 23,000 piles, 26,000 cords of brush, and 42,300 cubic yards of stone used.

The space over which the river can wander during low water is now limited in width to 2,500 feet, and there is every prospect that navigation in this locality will hereafter be materially improved.

Liberty.—This reach of the river commences at Waters Landing, 71 miles below St. Louis, and extends about 6 miles downstream. The work done here during the year consisted in the protection of the right bank of the river between Anchor Landing and Bishops Landing, and in the construction of a series of hurdles between this latter place and Jones Point. The revetment work was done in three sections and has

a total length of 7,250 feet. The upper section, 1,800 feet, is just above Anchor Landing, and is separated from the remainder by a space of 900 feet, which is occupied by a very shoal gravel bar, over which it seemed unnecessary to lay a mattress.

The remaining 5,450 feet is continuous, although placed in two sections, advantage being taken of two favorable stages of water. The stonework was carried above the mattress for its entire length to the 16-foot contour, no grading being attempted. As soon as high water has effected this the bank will be revetted to its top.

In the construction of this revetment there was used 7,000 cords of brush and 10,600 cubic yards of stone.

In the locality mentioned seven hurdles were constructed and their river ends strengthened and protected. The total length of these is 11,050 feet. In their construction there were used 9,000 piles, 13,400 cords of brush, and 20,400 cubic yards of stone.

Temporary expedients.—Some experience in temporary expedients for deepening channels across bars was had during last low-water season. The steamer *Gen. H. L. Abbot*, which is furnished with two jet pumps capable of throwing 5,000 gallons per minute each, was used with marked success at the crossing at the foot of Ste. Genevieve Bend and also at other points in that reach.

A very troublesome bar appeared during the low water of last season in the vicinity of Danby Landing. This was successfully improved in a few days by the expedient of a temporary movable jetty. This was made by first driving a row of piles 20 feet apart to mark the direction of the jetty and form a support for a number of small flats 40 feet in length, 16 feet wide, belonging to our plant and used for other purposes about the works. Extending down into the water from the upper side of these were a number of corrugated sheet steel panels, each 10 by 10 feet, made by riveting the steel to three angle bars 3 inches by 3 inches in section and 16 feet long. These projected above and below the sheets. Suitable arrangements were made for holding them against the flats.

A jetty 1,200 feet in length was built here in four days with a force of 22 men. The circumstances were such that it was necessary to build this across a shallow bar, leaving the water to pass around both ends. The effect was almost immediately shown. The channels commenced to deepen, and in a short time a depth of 6 feet was available for tows and 7 feet for single boats where 4 feet had been the best water. The river in the meantime had fallen 1 foot.

At the close of the season all of the material of which the jetty was made was removed.

The location of the work, briefly mentioned above, together with its character and extent, is shown definitely upon the plates herewith.

For more detailed information concerning it reference is invited to the reports, herewith forwarded, of the assistants in local charge of the work, with their accompanying tables, showing work done, localities, material used, etc.

Results of work done and condition of the river.—The main idea kept in view while carrying out the work projected for the improvement of the Mississippi River between the mouths of the Missouri and Ohio rivers has been to get control of it in the upper portion and then proceed downward, taking each reach where there has been excessive width and bad navigation at low water in succession. It has not been intended to complete the improvement in one locality before going to another, nor would this be desirable. The aim is to first improve the low-water navigation in the upper reach by confining the river within

the prescribed limits of 2,500 feet and giving it a proper direction of approach for passing through the next difficult reach below.

As this work progresses downward sufficient additions are made to the upper work to keep the river within the desired lines. By the time this process is carried to Cairo the newly made banks in the vicinity of St. Louis will have become sufficiently high by the deposition of sediment to receive their permanent revetment.

The river as far down as the foot of Liberty Reach, 80 miles below St. Louis, has now undergone the first step in its improvement. This is an addition of 32 miles during this fiscal year. During the last low-water season there was a channel depth of 6 feet maintained throughout the portion of the river then under improvement, with the exception of a very short time in two localities, and these were owing to a slight rise in the river followed by a sudden fall. The low-water season of last year was exceptionally long and the water exceptionally low. At one time during the season of navigation it was more than 5 feet below our standard plane of low water. In the unimproved portion of the river 3½ and 4 feet were the ruling depths during this time.

The next reach in which difficult navigation was experienced last season is in the vicinity of Devils Island, 116 miles below St. Louis and 65 miles above Cairo. This reach, and another extending from Commerce downstream about 7 miles, are the principal localities not yet improved, at which much difficulty is experienced during low water.

When the improvement of the river is completed in accordance with the project it is expected that a low-water channel 8 feet in depth will have been obtained. That it will be able to maintain itself at that depth at all times without the aid of dredging and other temporary expedients can not be asserted with positive certainty on account of the large quantities of sand and other sedimentary matter spasmodically emptied into the Mississippi River by the Missouri.

It is a matter of official record, derived from a series of sediment and discharge observations taken in 1879 at St. Charles on the Missouri River, that the amount of material brought down in suspension by that river, together with the sand rolled along the bottom, was sufficient during that year to have covered a space 1 mile square to a depth of 400 feet, or in other words, sufficient to fill a space 2,500 feet wide and 105 miles long to a depth of 8 feet; or would fill a street 100 feet wide, 53 miles long, to a height of nearly 400 feet.

Allusion is made in this manner to this record with the view to emphasizing the fact that there is a large quantity of material brought into the head of this reach of the Mississippi River every year which must be taken care of in some way, either used in building up the banks or passed through to Cairo and into the lower river. If the Missouri River, during a high stage, throws out more than an average quantity of this and then suddenly falls, the result is an engorgement of the improved channel of the Mississippi in certain localities which it must have time to push on down or work its way through. At such times movable dikes, dredges, and other temporary expedients will be necessary.

Plant.—The most important additions to the plant during the year were the towboat *Gen. H. L. Abbot*, fitted with pumps for jet dredging, and 12 model barges. These were constructed under contract, the former at a cost of $27,375, and the latter at a cost of $3,385 each.

The *Abbot* has a length of hull of 170 feet, width of 32 feet, and depth of hold of 5 feet, with suitable cabin and other parts; engines 20-inch diameter, 8-foot stroke; 4 boilers, each 42-inch diameter, 28 feet long, with 2 flues of 9½-inch diameter and 2 of 11-inch diameter; 2 duplex jet pumps 20 by 24 inch steam cylinder and 12 by 24 inch water cylinder, each

capable of delivering 5,000 gallons of water per minute. The boat is also supplied with an electric-light plant. The cost of the pumps and electric-light plant is not included in the contract price for the boat.

This boat was received from the contractor in August, 1895, since which time it has been in almost continuous use, and opportunity has been had for testing its various parts.

The barges are the usual style and model adopted for these works, 135 feet long, 28 feet beam, and 5 feet depth of hold. They are estimated to carry about 300 tons.

Other minor additions have been made to the plant during the year; also the current repairs, which, for so large an outfit as is required for these works, has aggregated a considerable amount.

Jet dredge boat.—On one of the model barges it is intended to mount two 15-inch centrifugal pumps of the Edwards Cataract pattern. These are each supplied with a direct-connection Ideal engine, 15 by 14 inches, for motive power. Two boilers, 42-inch shell, 28 feet long, with 4 flues, will furnish the steam. The suction pipes of these pumps will be over the sides and discharge over the bow of the barge. They are designed to throw about 20,000 gallons of water per minute through flattened nozzles upon sand bars, and thus wash the obstructing material into the deeper water below, making thereby a channel through the bars. The parts of this dredge are now in the process of being assembled and will be ready for operations early during the next low-water season.

For further details touching the plant reference is invited to the reports of Assistant D. M. Currie and C. D. Lamb, superintendent of the supply depot.

Physical investigations.—Water gauges have been read during the year under directions from this office at the following-named places, with the view to collecting data to be used in future investigations of the physical phenomena of the river and their bearing upon the work in progress, viz: Chain of Rocks, Bissells Point, St. Louis, United States Engineer Depot, Jefferson Barracks, Waters Point, Cornice Rock, Brickeys Mill, Little Rock, Kaskaskia, Chester, Bishop, and Greys Point.

The low-water season of the past year is notable for its duration and the extreme low stage which prevailed in the winter when navigation would have otherwise been free.

The stage was below the standard low water from September 27 to December 19. At this time there began a sudden rise which reached 23 feet on the St. Louis gauge. It fell again nearly to standard low water by the middle of January. Low stages prevailed until April 10, followed by medium and high stages, reaching 27.7 feet at St. Louis May 27.

It is evident that some change is taking place in the slope of the low-water surface of the river throughout those portions affected by the improvements in progress. With the view to ascertaining, if possible, the character and extent of this change, an investigation of the data at hand bearing upon the river between the Chain of Rocks and Cornice Rock was instituted. The results of this are set forth in the report of Assistant J. O. Holman, transmitted herewith. The data at hand and available for this investigation are entirely inadequate to anything like a proper scientific discussion of the subject or to a just conclusion as to what change is taking place in the regimen of the river as its improvement progresses.

The investigation indicates the direction in which additional data should be sought that may lead to useful results.

This work was in charge of Maj. C. J. Allen, Corps of Engineers, United States Army, until January 10, 1896. From that date to Jan-

uary 13 temporarily in charge of Lieut. Chester Harding, Corps of Engineers, United States Army, and since that date in charge of Maj. Thos. H. Handbury, Corps of Engineers, United States Army.

Mr. D. M. Currie has continued to discharge the duties of principal assistant engineer upon the work and Mr. Wm. S. Mitchell and Mr. Gerald Bagnall those of assistants in charge of the large field parties. The procuring of brush and quarrying of stone by hired labor was done by parties in charge of Mr. E. D. Libby, assistant engineer. The engineer depot, at which a large part of the supplies for the work is assembled and distributed and repairs to tools and minor repairs to the floating plant are made, has continued in charge of Superintendent C. D. Lamb. All these gentlemen have satisfactorily discharged their several duties.

ESTIMATE.

The original estimate of cost of the improvement of the Mississippi River between the mouth of the Ohio and the mouth of the Missouri River, as revised in 1883, is $16,397,500.

The aggregate amount of the funds appropriated and made available for this work to June 30, 1896, is $7,180,000.

LIST OF APPROPRIATIONS.

By act of—		By act of—	
June 10, 1872	$100,000.00	August 5, 1886	$375,000.00
March 3, 1873	200,000.00	August 11, 1888	300,000.00
June 23, 1874	200,000.00	September 19, 1890	400,000.00
March 3, 1875	200,000.00	July 13, 1892	525,000.00
August 14, 1876	200,000.00	March 3, 1893	658,333.33
June 18, 1878	240,000.00	August 18, 1894	758,333.33
March 3, 1879	200,000.00	March 2, 1895	758,333.33
June 14, 1880	250,000.00	June 3, 1896	275,000.00
March 3, 1881	600,000.00		
August 2, 1882	600,000.00	Total	7,359,999.99
July 5, 1884	520,000.00		

Of these amounts $180,000 was allotted by acts and projects for improvement between the Illinois and the Missouri rivers, including Alton Harbor, leaving a balance of $7,180,000, as stated above, to be applied to the project for the general improvement of the river between the mouth of the Missouri and the mouth of the Ohio River.

Of this amount there was on hand June 30, 1896, an available balance of $560,779.93, exclusive of outstanding liabilities. The amount that has been expended on the project to this date is, therefore, $6,619,220.07.

The amount expended during the fiscal year ending June 30, 1896, is $998,793.99.

This available balance includes the balances unexpended from special allotments made by Congress, as follows:

For bank protection at Cairo, Ill., act of July 5, 1884	$8,600
For continuing improvement at Cape Girardeau, Mo., act of August 5, 1886	22,500
For bank protection on east side of Mississippi River opposite to mouth of Missouri River, act of June 3, 1896	50,000
For removing bar in front of Chester, Ill., and protecting west bank of river opposite Chester, act of June 3, 1896	30,000
Total	111,100

The river and harbor act of June 3, 1896, appropriates the sum of $275,000 for carrying on continuously the systematic improvement of this portion of the river, and it also authorizes an additional $325,000 to be expended during the fiscal year ending June 30, 1897, and during each of the three succeeding years $673,333.33.

In addition to the special allotments for revetting the east bank of

the river opposite the mouth of the Missouri, and removing a bar at Chester and revetting the bank opposite, the act also provides—

That any balance of former appropriations now available, and the money hereby appropriated and authorized to be expended for the said section of said river between the mouth of the Missouri River and the mouth of the Ohio River, or so much thereof as may be necessary, shall be expended in the construction of suitable dredge boats, portable jetties, and other suitable appliances, and the maintenance of the same, with the view to ultimately obtaining and maintaining a navigable channel from St. Louis to Cairo not less than 250 feet in width and 9 feet in depth at all periods of the year, except when navigation of the river is closed by ice.

The expense of carrying out this provision, which contemplates a resort to temporary expedients for the relief of navigation until the more permanent work contemplated by the original project has been done and produced its results, can not at this time be estimated. It should not be charged to the estimate for the original work.

The balance of the estimate for the original project not yet appropriated amounts to $9,217,500.

The balance available June 30, 1896, $560,779.93, together with the additional $325,000 authorized by the act of June 3, 1896, to be expended during the fiscal year ending June 30, 1897, if appropriated, will be expended in carrying out the original project as modified by the provisions of that act. It is proposed during the coming low-water season to provide dredges, portable jetties, and devices of a similar character sufficient to insure at least 6 feet depth of channel from St. Louis to Cairo.

It is estimated that the sum of $800,000 can be profitably expended during the fiscal year ending June 30, 1898, in the work of the original project and in the temporary work required by the river and harbor act of June 3, 1896.

This work is in the collection district of New Orleans. The nearest port of entry is St. Louis, Mo., at which place the customs collected during the fiscal year ended June 30, 1896, amounted to $1,129,966.56.

The amount of internal revenue collected was $6,469,443.88.

Money statement.

July 1, 1895, balance unexpended		$1,332,305.07
Amount appropriated by act of June 3, 1896		275,000.00
		1,607,305.07
June 30, 1896, amount expended during fiscal year		998,793.99
July 1, 1896, balance unexpended		608,511.08
July 1, 1896, outstanding liabilities	$9,846.75	
July 1, 1896, amount covered by uncompleted contracts	37,884.40	
		47,731.15
July 1, 1896, balance available		* 560,779.93
Amount (estimated) required for completion of existing project		9,217,500.01
Amount that can be profitably expended in fiscal year ending June 30, 1898		800,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		

*Of this balance amounts have been allotted by mandatory acts of Congress as follows:

Bank protection at Cairo, Ill., act July 5, 1884 (balance)	$8,600.00
Continuing improvement at Cape Girardeau, Mo., act August 5, 1886 (balance)	22,500.00
Removing bar in front of Chester, Ill., and protecting west bank of river opposite Chester, act of June 3, 1896	30,000.00
Total	61,100,00
Mississippi River opposite mouth of Missouri River (not mandatory. To be expended at discretion of Secretary of War)	50,000.00
Total	111,100.00

Abstract of proposals for piles received in response to advertisement dated July 25, 1895, and opened August 9, 1895, by Maj. Charles J. Allen, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	First-class piles (price per foot).				Amount.
		2,000, 36 to 40 feet.	2,000, 41 to 45 feet.	1,500, 46 to 50 feet.	500, 51 to 65 feet.	
		Cents.	*Cents.*	*Cents.*	*Cents.*	
1	John Cleary, Chester, Ill	.....	.....	.....	.....	.....
2	James M. Craig, Cape Girardeau, Mo	11½	11½	11½	11½	$30,245

No.	Name and address of bidder.	Second-class piles (price per foot).						Amount.
		500, 25 to 30 feet.	1,000, 31 to 35 feet.	1,500, 36 to 40 feet	1,500, 41 to 45 feet.	1,000, 46 to 50 feet.	500, 51 to 65 feet.	
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	
1	John Cleary, Chester, Ill	7	7	7	7	7	6½	$17,022.50
2	James M. Craig, Cape Girardeau, Mo.	7¼	7¼	7¼	7¼	7¼	7¼	17,780.62

No. 1, lowest; acceptance recommended for second-class piles.
No. 2, only bid for first-class piles; rejection recommended.
Amount available, $193,000 from appropriation of August 18, 1894, and also $758,333.33 from appropriation of March 2, 1895.

Abstract of proposals for piles received in response to advertisement dated February 12, 1896, and opened March 13, 1896, by Maj. Thos. H. Handbury, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	First-class piles (price per foot).				Amount.
		1,500, 36 to 40 feet.	1,500, 41 to 45 feet.	1,500, 46 to 50 feet.	500, 51 to 65 feet.	
		Cents.	*Cents.*	*Cents.*	*Cents.*	
1	John Cleary, Chester, Ill	.....	.....	.....	.....	.....
2	Frederick Hartweg, Cincinnati, Ohio	10⅜	10⅜	10⅜	10⅜	$23,084.37
3	P. S. McCann, Grand Tower, Ill	.....	.....	.....	.....	.....
4	J. H. Bethune, St. Louis, Mo	15	15	15	20	34,825.00

No.	Name and address of bidder.	Second-class piles (price per foot).						Amount.
		500, 25 to 30 feet.	1,000, 31 to 35 feet.	1,000, 36 to 40 feet.	1,000, 41 to 45 feet.	1,000, 46 to 50 feet.	500, 51 to 65 feet.	
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	
1	John Cleary, Chester, Ill	6½	7	7	7	7	7	$14,263.75
2	Frederick Hartweg, Cincinnati, Ohio	6⅝	6⅝	6⅝	6⅝	6⅝	6⅝	13,564.68
3	P. S. McCann, Grand Tower, Ill	7¼	7¼	7¼	7¼	7¼	7¼	14,844.37
4	J. H. Bethune, St. Louis, Mo	12	12	13	13	15	15	27,690.00

Acceptance recommended of bid No. 2.
Amount available, $550,000; appropriated by act of March 2, 1895.

Abstract of proposals for stone received in response to advertisement dated February 12, 1896, and opened March 13, 1896, by Maj. Thos. H. Handbury, Corps of Engineers, at St. Louis, Mo.

No.	Name and address of bidder.	Quantity offered.	Price.	Amount.	Location.
		Cubic yds.	*Cents.*		
1	Nelson Sisson, Grand Tower, Ill.	10,000	52	$5,200	Opposite Grand Tower, Ill.
2	Bennett James, Mitchie, Ill.....	20,000	52	10,400	Stone quarry on bank of river just above the penitentiary at Chester, Randolph County, Ill.
3	Earl E. Burke, Louisville, Ky..	20,000	58	11,600	Brickeys Mill, Mo.
4	Joseph M. Horine, Chester, Ill..	30,000	48	14,400	Menard, Randolph County, Ill.
5	Martin Lorenz, St. Louis, Mo...	20,000	52	10,400	Foot Cahokia street, St. Louis, Mo.
6	Albert Bussen, Oakville, Mo ...	10,000	52	5,200	Quarantine, Mo.

Acceptance recommended of bids Nos. 5 and 6.
Amount available, $550,000; appropriated by act of March 2, 1895.

CONSTRUCTION.

Cost of works during fiscal year ending June 30, 1896.

Labor, plant, and material.	Hurdles.	Protection.	Dredging and portable jetties.	Total.
Labor, superintendence, etc	$179,370.79	$27,434.66	.....	$206,805.45
United States Engineer Office	11,340.85	1,304.02	.....	12,644.87
General expenses	11,473.88	1,388.88	.....	12,862.76
Plant	26,312.18	2,328.75	.....	28,640.93
Material	11,266.09	1,024.38	.....	12,290.47
Surveys	3,288.83	676.48	.....	3,965.31
Steamer Gen. Gillmore	3,304.77	650.84	.....	3,955.61
Steamer Gen. T. L. Casey	3,443.12	390.71	.....	3,833.83
Steamer Gen. H. L. Abbot	557.01	.....	.....	557.01
Steam tenders	5,249.54	260.25	.....	5,509.79
Barges	1,207.12	.....	.....	1,207.12
Quarter barges	1,734.70	359.77	.....	2,094.47
Quarter boats	2,161.31	426.76	.....	2,588.07
Office and survey boats	1,139.77	139.19	.....	1,278 96
Pile drivers	20.428.57	750.36	.....	21,178.93
Machine shop	317.80	.....	.....	317.80
Small boats	19,497.79	2,066.22	.....	21,564.01
Portable quarters	556.77	132.81	.....	689.58
Portable jetties	.....	.....	$9,680.45	9,680.45
Supply depot	735.42	192.78	.....	928.20
Tools and appliances	5,154.18	1,007.48	.....	6,161.66
Boarding outfit	4,617.62	733,36	.....	5,350.98
Office furniture	48.01	.....	.....	48.01
Subsistence	49,513,92	7,557.57	.....	57,071.49
Brush	96.889.99	25,577.93	.....	122,467.92
Piles	139,558.66	158.76	.....	139,717.42
Stone	95,981.85	26,430.97	.....	122,412.82
Rope	2,490.39	628.67	.....	3,119.06
Wire	6,464.65	1,051.21	.....	7,515.86
Iron	47.29	.50	.....	47.79
Nails	678.50	103.43	.....	781.93
Spikes	2,428.47	321.20	.....	2,749.67
Bolts	223.72	.....	.....	223.72
Clevises	877.24	.....	.....	877.24
Lumber	363.68	59.68	.....	423.36
Oakum	18.06	2.19	.....	20.25
Coal	12,606.77	764.23	.....	13,371.00
Coal, blacksmith's	8.32	.83	.....	9.15
Ice	1,083.12	277.44	.....	1,360.56
Material, miscellaneous	2,992.36	329.15	.....	3,321.51
Total	725,433.11	104,531.46	9,680.45	839,645.02

Distributed as follows:

Locality.	Hurdles.	Protection.	Dredging and portable jetties.	Total.
Horsetail Bar	.....	$2,095.85	.....	$2,095.85
Twin Hollows, west side	.....	8,466.62	.....	8,466.62
Sulphur Springs	$38,669.84	.....	.....	38,669.84
Foster Island	.....	1,881.47	.....	1,881.47
Lucas	141,988.57	.....	.....	141,988.57
Cornice Island	17,401.43	.....	.....	17,401.43
Michaels	32,096.04	.....	.....	32,096.04
Danbys	.....	25,190.80	$7,286.06	32,476.86
Bruce Island	.....	3,971.99	.....	3,971.99
Crooks	39,829.94	.....	.....	39,829.94
Turkey Island	.....	23,309.33	.....	23,309.33
Ste. Genevieve, Ill	119,422.98	.....	.....	119,422.98
Ste. Genevieve, Mo	195,513.56	.....	.....	195,513.56
Ste. Genevieve	.....	.....	2,394.39	2,394.39
Moro Island	.....	1,045.26	.....	1,045.26
Liberty Island	140,510.75	38,570.14	.....	179,080.89
Total	725,433.11	104,531.46	9,680.45	839,645.02

Total cost of works to June 30, 1896.

Name of work.	Expended—		Total.
	Prior to July 1, 1895.	During year 1895–96.	
Sawyer Bend, protection	$96,803.63	.....	$96,803.63
Venice Dikes	36,341.85	.....	36,341.85
St. Louis Harbor	144,048.94	.....	144,048.94
Arsenal Island, protection	42,599.06	.....	42,599.06
Closing Cahokia Chute	119,958.21	.....	119,958.21
Channel opposite St. Louis	58,455.54	.....	58,455.54
Horsetail Bar, Dikes 1 to 5, inclusive	225,066.31	.....	225,066.31
Horsetail Bar, training wall	81,253.28	.....	81,253.28
Horsetail Bar, hurdles	618,447.68	.....	618,447.68
Horsetail Bar, bank protection	66,536.57	$2,095.85	68,632.42
Carrolls Island, hurdles	40,343.98	.....	40,343.98
Twin Hollows, west side, hurdles	315,611.64	.....	315,611.64
Twin Hollows, west side, bank protection	48,101.04	8,466.62	56,567.66
Twin Hollows, east side, bank protection	129,435.57	.....	129,435.57
Pulltight, hurdles	519,185.10	.....	519,185.10
Pulltight, bank protection	1,818.23	.....	1,818.23
Beards Island, primary hurdle	7,166.24	.....	7,166.24
Beards Island, bank protection	84,258.76	.....	84,258.76
Chesley Island, hurdles	27,808.61	.....	27,808.61
Chesley Island, bank protection	73,916.55	.....	73,916.55
Jim Smiths, hurdles	365,803.33	.....	365,803.33
Jim Smiths, bank protection	7,569.58	.....	7,569.58
Sulphur Springs, hurdles	317,582.55	38,669.84	356,252.39
Foster Island, protection	44,756.02	1,881.47	46,637.49
Lucas, hurdles	130,814.25	141,988.57	272,802.82
Cornice Island, hurdles	46,143.84	17,401.43	63,545.27
Rush Tower, hurdles	218,267.90	.....	218,267.90
Michaels, hurdles	97,073.15	32,096.04	129,169.19
Rush Tower, bank protection	82,312.83	.....	82,312.83
Danbys, dredging and portable jetties	.....	7,286.06	7,286.06
Danbys, bank protection	.....	25,190.80	25,190.80
Fort Chartres, dam	36,812.86	.....	36,812.86
Fort Chartres, west side, hurdles	225,883.99	.....	225,883.99
Fort Chartres, west side, bank protection	19,458.12	.....	19,458.12
Bruce Island, bank protection	.....	3,971.99	3,971.99
Fort Chartres, east side, bank protection	39,846.88	.....	39,846.88
Fort Chartres, dredging and portable jetties	5,478.40	.....	5,478.40
Crooks	.....	39,829.94	39,829.94
Turkey Island, dam	24,463.85	.....	24,463.85
Turkey Island, bank protection	5,520.00	23,309.33	28,829.33
Ste. Genevieve, Ill., hurdles	147,823.46	119,422.98	267,246.44
Ste. Genevieve, Ill., bank protection	26,189.35	.....	26,189.35
Ste. Genevieve, Mo., hurdles	20,222.40	195,513.56	215,735.96
Ste. Genevieve, dredging and portable jetties	.....	2,394.39	2,394.39
Moro Island, bank protection	.....	1,045.26	1,045.26
Kaskaskia, bank protection	66,465.62	.....	66,465.62
Liberty Island, dam	5,053.91	.....	5,053.91
Liberty Island, bank protection	45,129.40	38,570.14	83,699.54
Liberty Island, hurdles	.....	140,510.75	140,510.75

Total cost of works to June 30, 1896—Continued.

Name of work.	Expended— Prior to July 1, 1895.	Expended— During year 1895-96.	Total.
Devils Island, Dike No. 1	$65,871.17	.....	$65,871.17
Devils Island, Dams 1 and 2	66,526.88	.....	66,526.88
Devils Island, dredging and portable jetties	3,004.14	.....	3,004.14
Minton Point, hurdles	33,436.37	.....	33,436.37
Cape Girardeau, primary hurdles	31,930.18	.....	31,930.18
Cairo, bank protection	160,439.82	.....	160 439.82
Total	5,077,037.04	$839,645.02	5,916,682.06

PROPERTY ACCOUNT.

Class of property.	Value July 1, 1895.	Debits.	Credits.	Value June 30, 1896.
Steamer Gen. Gillmore	$15,541.30	$24,544.58	$24,715.96	$15,369.92
Steamer Gen. T. L. Casey	24,589.60	24,772.91	26,452.92	22,909.59
Steamer Gen. H. L. Abbot	1,437.16	57,050.95	19,321.89	39,166.22
Dredge No. 1	.....	1,516.07	.....	1,516.07
Steam tenders	26,209.92	5,911.81	5,914.07	26,207.66
Barges, model	126,360.31	54,564.13	29,692.04	151,232.40
Barges, quarter	16,111.42	788.00	4,232.87	12,666.55
Quarter boats	49,884.32	539.76	3,397.63	47,026.45
Office and survey boats	15,467.97	235.89	1,444.33	14,259.53
Pile drivers	130,178.00	20,293.00	23,603.49	126,867.51
Derrick boats	4,173.65	34.62	734.62	3,473.65
Derricks	1,759.77	352.04	287.46	1,824.35
Machine shop	1,287.97	1,488.56	1,733.27	1,043 26
Small boats	44,311.75	11,438.15	24,006.51	31,743.39
Portable quarters	4,898.21	1,304.03	2,032.64	4,169.60
Portable jetties	2,714.02	8,212.92	7,077.95	3,848.99
Ways (supply depot)	2,903.83	735.12	1,286.84	2,352.11
Supply depot	4,537.60	1,174.13	1,616.54	4,095.19
Tools and appliances	13,041.71	13,590.33	10,155.90	16,476.14
Boarding outfit	26,455.49	8,014.94	6,719.17	27,751.26
Office furniture	480.13	140.00	48.01	572.12
Survey instruments	1,921.76	190.00	211.18	1,900.58
Photographic apparatus	257.14	.....	.....	257.14
Total	514,523.03	236,891.94	194,685.29	556,729.68

MATERIAL ACCOUNT.

Class of material.	Value July 1, 1895.	Debits.	Credits.	Value on hand June 30, 1896.
Subsistence	$3,226.23	$83,321.09	$84,518.27	$2,029.05
Brush	7,311.33	118,690.70	122,467.92	3,534.11
Piles	786.13	140,491.41	140,278.91	998.63
Stone	131.86	124,969.85	122,412.82	2,688.89
Rope	22,346.50	11,190.28	5,962.93	27,573.85
Wire	562.80	9,454.52	7,525.53	2,491.79
Iron	2,644.66	3,742.36	2,846.70	3,540.32
Nails	317.63	2,131.95	975.33	1,474.25
Spikes	1,829.65	2,874.76	2,985.08	1,719.33
Bolts, screws	1,363.35	.....	391.24	972.11
Bolts, assorted	61.87	.....	15.01	46.86
Clevises	789.13	534.77	877.24	446.66
Lumber	2,409.86	11,265.28	8,086.79	5,588.35
Lumber (linear feet)	23.30	2.00	23.56	1.74
Oakum	707.77	915.00	1,155.09	467.68
Coal	1,081.17	36,219.49	35,173.91	2,126.75
Coal, blacksmith's	32.27	174.14	171.23	35.18
Ice	.....	4,391.67	4,391.67	.....
Material, miscellaneous	7,941.97	36,513.68	33,371.95	11,083.70
Total	53,567.48	586,882.95	573,631.18	66,819.25

COMMERCIAL STATISTICS.

Receipts and shipments at St. Louis, Mo, during the years 1892, 1893, 1894, and 1895.

Articles.	Receipts.				Shipments.			
	1892.	1893.	1894.	1895.	1892.	1893.	1894.	1895.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Barbed wire, ores, and metals (pig and manufactured)	16,768	11,357	23,942	24,759	3,574	7,912	2,066	2,373
Cement	1,238	13,429	7,718	11,026	.....	.....	.....	.....
Coal and coke	85,547	23,180	26,625	18,785	10,504	28,874	76,055	47,402
Cotton and products	1,462	903	2,249	1,583	22	19	16	11
Groceries and dairy products	18,382	22,868	20,407	16,481	13,919	11,789	9,479	11,645
Hay, seed, grain, flour, meal, etc	76,376	77,709	77,489	67,586	314,336	274,201	148,477	123,734
Live stock and products	14,953	13,392	14,820	20,623	10,040	7,631	9,955	10,305
Lumber	159,140	126,510	228,087	189,721	7,000	6	3,135	4,452
Merchandise and sundries	310,370	304,099	175,633	138,317	138,250	95,699	105,261	94,459
Vegetables and fruits	2,559	5,440	6,133	19,321	2,132	3,210	1,878	3,273
White lead, oils, etc	12	68	48	63	1,786	1,513	1,356	1,828
Wines and liquors	64	181	79	75	631	6,038	5,383	3,852
Wool	329	269	280	490	21	8	19	21
Total	687,200	599,405	583,510	508,830	502,215	436,900	363,080	303,355

Transferred by ferries across the river at St. Louis.

	Tons.		Tons.
1892	2,760,187	1894	2,826,859
1893	2,829,053	1895	2,809,791

Shipments down the river from landings between St. Louis and Cairo during the years 1892, 1893, 1894, and 1895.

Grain, including flour, meal, etc.:	Tons.
1892	18,990
1893	21,294
1894	57,120
1895	26,715

RECAPITULATION.

	1892.	1893.	1894.	1895.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Receipts and shipments at St. Louis	1,189,415	1,036,305	946,590	812,185
Transferred by ferries at St. Louis	2,760,187	2,829,053	2,826,859	2,809,791
Shipped from landings between St. Louis and Cairo	18,990	21,294	57,120	26,715
Total	3,968,592	3,886,652	3,830,569	3,648,691

List of steam-power boats that arrived at St. Louis during the year 1895.

Size of boats.	Draft.	Boats.	Times arrived.
	Feet.		
Under 500 gross tons	2.5 to 6	87	1,380
Between 500 and 1,000 gross tons	4 to 8	17	530
Over 1,000 gross tons	6.7 to 9.5	10	555
Total	.....	114	2,465

List of barges and scows that arrived at St. Louis during the year 1895.

Size of boats.	Draft.	Barges and scows.	Times arrived.
	Feet.		
Under 500 gross tons	2.5 to 7.5	143	833
Between 500 and 1,000 gross tons	5.2 to 8	21	67
Over 1,000 gross tons	5.3 to 9	52	111
Total	.....	216	1,011

List of steamers and barges permanently and temporarily enrolled and licensed at the port of St. Louis December 31, 1895.

	Vessels.	Gross tonnage.	Net tonnage.
Permanently enrolled:			
Steamers (wood)	99	37,746.14	37,174.37
Barges	86	80,867.88	80,777.04
Steamers (iron)	4	1,690.29	1,639.82
Temporarily enrolled steamers (wood)	1	53.83	53.82
Permanently licensed:			
Barges under 20 tons	2	27.79	27.79
Steamers under 20 tons (wood)	8	135.21	101.44
Steamers under 20 tons (iron)	1	26.92	13.46
Yachts under 20 tons	3	30.23	25.77
Total	204	120,578.29	119,843.51

REPORT OF MR. D. M. CURRIE, ASSISTANT ENGINEER.

ST. LOUIS, MO., *June 30, 1896.*

MAJOR: I have the honor to submit the following report upon the improvement of the Mississippi River between the Missouri and Ohio rivers for the fiscal year ending June 30, 1896.

This work was begun in 1872 and was prosecuted as funds were available by constructing solid dikes and dams to close chutes and contract excessive widths and by revetment to protect banks at several localities until 1880. The project approved in 1881, of which all subsequent projects are a continuation, proposed to carry the improvement continuously downstream from St. Louis and substituted permeable hurdles for the solid dikes and dams.

A summary of the work done prior to the beginning of this year may be found in the Annual Report of the Chief of Engineers for the fiscal year ending June 30, 1895, page 2059 et. seq.

In carrying the improvement downstream in accordance with approved projects, works have been prosecuted at several localities between St. Louis and Liberty Island, a distance of about 80 miles. The navigable channel has been greatly improved within this reach; further work, however, will be required at many localities to complete the improvement and secure its permanency.

The localities at which permanent work was prosecuted this year are as follows: Horsetail, west; Twin Hollows, west; Sulphur Springs, Foster Island, Lucas, Cornice Island, Michaels, Danbys, Bruce Island, Crooks, Turkey Island, Ste. Genevieve (Illinois and Missouri), Liberty, and as auxiliary thereto movable jetties were placed at Danbys and dredging was done at Ste. Genevieve to hasten results and give temporary relief to navigation.

The work was carried on by hired labor with plant owned by the United States, material was procured by hired labor, purchased in open market and by contract, following in each case the method most economical and advantageous to the Government.

The plant was repaired as required and additions were made thereto as provided for in approved projects.

The gauges were read daily, and that at St. Louis ranged between 4 feet below and 24 beet above standard low water.

A survey was made during the low-water season extending from St. Louis, Mo., to Redrock, Mo., about 90 miles below, or about 10 miles farther than the continuous improvement has been extended. The discharge of the river was measured with the gauge at St. Louis 1.3 feet below standard low water.

The least depth as obtained from pilots' reports was 3½ feet at Allens Towhead, within the unimproved reach.

Horsetail, west.—The revetment was extended up to the foot of the bluff bank, about 14 feet above standard low water, to a distance of 1,500 feet below Dike No. 1.

Twin Hollows, west.—At this locality two sections of mattress, aggregating 2,120 feet in length, were fabricated and sunk for the protection of the bank below standard low water and the bank above was partly revetted.

Sulphur Springs.—The work at this locality comprised the completion, extension, and strengthening of hurdles Nos. 13, 14, 15, 15½, and 18, as follows:

In No. 13 the clumps of piles were doubled and the hurdle was braced to a distance of 180 feet from its river end. No. 14 was braced to a distance of 300 feet from its river end and the clumps were doubled 280 feet farther. The clumps in No. 15 were doubled throughout its entire length and the hurdle was braced to a distance of 265 feet from its river end. Double clumps were driven and braces were placed to a distance of 220 feet from the river end of No. 15½. The revetment at the shore ends of Nos. 14, 15, and 18 were extended up the bank to about 18 feet above standard low water.

Foster Island.—A portion of the revetment placed in 1882 and 1883 was repaired and extended up the bank to the stage of about 11 feet above standard low water.

Lucas.—At this locality the work comprised the building of Hurdles Nos. 0, 0½, 1½, 2½, 3¼, 3½, 4½, 5½, and 6, to reestablish the efficiency of the series built there during the fiscal year 1889–90, and Nos. 7, 9, 11, 13, and 15 in extending the series downstream. Hurdles Nos. 0 to 7, inclusive, were in deep water, with a swift current setting strongly toward shore, and in consequence they were strengthened by double clumps of piles and buttresses, as follows: Nos. 0, 0½, 2½, 4½, and 7 were double clumped through their entire length; Nos. 1½, 3¼, 3½, 5½, 6, and 9 to a distance of 500, 130, 150, 220, 175, and 300 feet, respectively, from their river ends, and No. 11 to a distance of 1,025 feet from its shore end. Buttresses were built on the river ends of Nos. 0, 0½, 1½, 2½, 3¼, 3½, 4½, 5½, 6, and 7. All of this work was done during the low-water season of the fall and the early spring, and many of the lines could not be connected with the high bank, nor could Nos. 13 and 15 be extended to their river ends.

Cornice Island.—The work at this locality was the completion of a series of five hurdles, Nos. 1, 2, 3, 4, and 5, begun during the preceding year. (See page 2059 et seq., Report of the Chief of Engineers for 1895.) On account of their exposed situation, these hurdles were strengthened by double clumps of piles, buttresses at their river ends, and by heavy revetment at their shore ends.

Michaels.—The work at Michaels comprised the repair and completion of Hurdle No. 1 and the extension of Hurdle No. 3. The direction of No. 3 was deflected downstream to connect with the upper end of Perrys Towhead, which gave it an inclination to the stream that caused considerable current along its front; the width of the mattress was therefore increased to 130 feet to prevent scour. The head of the towhead was protected by mattress placed below the water surface and revetment above to the top of the bank.

Danbys.—The work at Danbys Landing was the protection of the Missouri bank, which had eroded to the proposed limit line in accordance with the project approved in 1892. The protection, placed during the low-water season, consisted of a mattress below water surface and revetment above to a distance of 4,750 feet below Danbys Landing. The revetment was extended up to the foot of the bluff bank about the stage of 12 feet above standard low water.

Bruce Island.—The revetment at Bruce Island was extended throughout its entire length of 3,350 feet up to the foot of the bluff bank about the stage of 12 feet above standard low water.

Crooks.—The work at Crooks Landing comprised a series of four hurdles, which had been in contemplation since 1892, when the project for this work was approved, but the construction of which had been delayed to await results of other works in that vicinity. This work was done during the low-water season, when the river ends of some of the hurdles either rested upon dry sand bars or were inaccessible on account of the small depths of water. On this account Nos. 1 and 2 could not be extended to their projected lengths. Nos. 0 and —1 were built with extra strength throughout their lengths with buttresses at their river ends. These hurdles were built in the usual form, except that on 500 feet of their lengths next to their river ends the height of the piling sloped from 21 feet to 11 feet above standard low water.

Turkey Island.—The work at Turkey Island was the extension of the protection to the west face of the island about 4,050 feet downstream, making a total length of 5,250 feet, with mattress of usual form placed below water surface and revetment above to 11 feet on 2,500 feet of the upper end, dropping to 4 within the next 750 feet, and then to 1 foot above standard low water on the remaining distance of 2,000 feet.

Ste. Genevieve, Illinois and Missouri.—The work at Ste. Genevieve comprises a series of hurdles on each side of the river and the protection of the channel frontage of

Moro Island. Hurdles Nos. 2, 3, and 4 of the Illinois series were built during 1891 and 1892 in accordance with requirements of the river and harbor act of 1890 to prevent the channel leaving Little Rock, the landing for Ste. Genevieve. These having been incorporated into the works for the general improvement of the river were partially repaired when the series was extended downstream during 1895. (See page 2059 et. seq., Report of the Chief of Engineers for 1895.) The repairs were fully completed and the series was extended further downstream during this fiscal year by the construction of Nos. 6, 8, 10, 12, 15, 16, 17, 18½, 20, and 22; Nos. 15, 16, and 17, damaged during the high water, were repaired. Buttresses were built above the river ends of Nos. 2, 3, 4, 6, 8, 10, 12, 16, 17, 20, and 22 and two additional ones on No. 12 on account of its exposed condition. All of these lines were curtained, drift was sunk throughout the entire length of Nos. 6, 8, and 12 and across the deep water on Nos. 10 and 15. The shore ends of all these hurdles were protected by mattress and revetment. The protection of Moro Island was extended up to the foot of the bluff bank upon a short section at its lower end.

The Missouri series was extended downstream by completing Hurdles Nos. 2 and 3 and building wholly or in part Nos. 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, and 15, as follows: Nos. 4, 7, 8, and 10 were completed to their full lengths; Nos. 8 and 10 being exposed, their river ends were protected by buttresses; Nos. 5 and 6 were completed only to about half their projected lengths; in No. 11 only a short section near shore was built; Nos. 12, 14, and 15 were well advanced, but not completed at the close of the year.

Liberty.—The work at Liberty comprised the protection of the bank between Anchor Landing and the old revetment above Bishops, and a series of hurdles below to Jones Point. The total length of protection, 7,290 feet, was placed in two sections with 900 feet between where the bank was composed of hard gravel which stood without protection. The protection consisted of a mattress placed below water surface and revetment above to the foot of the bluff bank at about the stage of 12 feet above standard low water.

Hurdles Nos. 1, 2, 3, 4, 5, 7, and 10 were built and their river ends protected and strengthened by double clumps and by pile buttresses of half T-heads.

Auxiliary work.—Upon the approach of the low-water season, about the last of September, several bars developed with no more than 4 feet depth of water in the channel crossing them, notably at Danbys, foot of St. Genevieve Bend, Liberty, Devils Island, and Allens Towhead.

Partial relief was afforded by means of movable jetties and dredging. All of these bars were serious obstructions to navigation, but none more so than Danbys, and therefore a movable jetty 1,200 feet long, composed of aprons supported by flats resting against piles was placed on the lower reef of the best channel crossing the bar. The width of the waterway at the low stage of river which then prevailed was 2,200 feet and this was reduced by the jetty to 1,000 feet, leaving 300 feet west and 700 feet east of the jetty, known as the upper and lower ways, respectively.

The jetty caused a scour to a depth not less than 7 feet in both the upper and lower ways, but the lower soon became the wider and better channel for the passage of large tows, although there was sufficient width for single boats in the upper way. The jetty was left in position until the close of the working season, about the middle of November, and was then removed. The piles were drawn and returned to the stock for general use in the permanent improvement, the aprons were stored at the engineer depot for further use when needed.

Dredging.—The crossing at the foot of Ste. Genevieve Bend became in the early part of November one of the shoalest and most difficult to navigate between St. Louis and the Ohio River. The channel depth was scant 4 feet, while on account of the lapping of reefs the approach was difficult. The *Gen. H. L. Abbot* was taken there November 12 and dredged the channel during the afternoon, increasing the depth to 5 feet. On the 13th the *Abbot* worked until noon rounding off the points of the reef so that ascending steamers could enter with less difficulty.

The *Abbot* was also used with satisfactory results at Ste. Genevieve, expediting the completion of hurdles on the Missouri side by dredging in the contemplated channel through the works.

Procuring materials.—Of the brush required 6,277.6 cords were procured by contract and the remainder, 71,976.8 cords, by hired labor. The stone required was 149,796.4 cubic yards, of which 97,612.6 cubic yards were procured by hired labor and the remainder by contract and purchase in open market. The number of piles required was 47,128, which were procured by contract and by purchase in open market. Other materials and supplies were purchased as required in open market.

Plant.—Important additions have been made to the plant, including the steamer *Gen. H. L. Abbot*, 12 model barges, and 1 steam derrick. The construction of a jet dredge and additional aprons for movable jetties was begun.

The steamer *Gen. H. L. Abbot* was sunk, raised, and thoroughly repaired. The *Gen. Gillmore*, barges Nos. 106, 107, 109, and 112, pile driver No. 18, and 54 skiffs received considerable repairs. All other plant, including engineer depot, tools, and appliances, was repaired as required.

Gauges.—The gauges established by this office to determine changes resulting from the improvement have been read daily. They show that decided changes have taken place, but the extent of such changes can be determined only after a long series of gauge readings and discharge measurements, both before and after the construction of works for the improvement.

Stages of water.—The low-water season of this year was notable both for duration and the extremely low stage reached during the winter period, when navigation would otherwise have been open. The stage was below standard low water from September 27 to December 19, when there was a sudden rise to 23 feet on the St. Louis gauge, falling again nearly to standard low water by the middle of January. Low stages prevailed until April 10, followed by medium and high stages, reaching 27.7 feet at St. Louis May 27.

Condition of the river.—By the operations of this year the improvement of the river below St. Louis has been well advanced to Liberty, a distance of 80 miles. Further work, however, will be required at many localities within this reach.

This reach before improvement contained a number of shoal bars, some of which were as shoal as any between the Missouri and Ohio rivers. During the low-water season of this year about 6 feet was the prevailing minimum channel depth within the reach, while 3½ and 4 feet depths were found in the unimproved portion.

Form of construction.—No material change has been made in the form of construction of either hurdles or bank protection described in the Annual Report of the Chief of Engineers for 1895, page 2059 et seq.

Accompanying reports.—Further details are shown in reports of assistants in local charge, as follows: Upon works at Horsetail, Twin Hollows, Sulphur Springs, Foster Island, Lucas, Cornice Island, and hurdles at Liberty, in the report of Mr. Gerald Bagnall, assistant engineer; upon works at Michaels, Danbys, Bruce Island, Crooks, Turkey Island, Ste. Genevieve, and bank protection at Liberty, in the report of Mr. William S. Mitchell, assistant engineer; upon procuring materials, brush, and stone by hired labor, in the report of Mr. E. D. Libby, assistant engineer; upon gauge relations at medium and low stages, in the report of Mr. John O. Holman, assistant engineer; and upon plant, material, and supplies, in the report of Mr. C. D. Lamb, superintendent supply depot.

Plates.—For further information this report refers to plates numbered 1*, 2, 3, 4, 5, 6, 7, and 8.* No. 1 is a map of the river from the Missouri River to Red Rock, about 90 miles below Eads Bridge, St. Louis, on a scale of 1:100,000, showing location of works constructed and those projected. Plates 2 to 6, on a scale of 1:25,000, are maps showing the location and the extent of works built during this fiscal year as follows: Plate No. 2, Twin Hollows; No. 3, Sulphur Springs, Foster Island, Lucas, and Cornice Island; No. 4, Michaels and Bruce Island; No. 5, Crooks, Turkey Island, and Ste. Genevieve; No. 6, Liberty. Plates Nos. 7 and 8 are profiles of the river between St. Louis and Cornice Island.

Very respectfully, your obedient servant,

D. M. CURRIE, *Assistant Engineer*

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

REPORT OF MR. WILLIAM S. MITCHELL, ASSISTANT ENGINEER, ON WORKS AT MICHAEL LANDING, DANBY LANDING, BRUCE ISLAND, CROOK LANDING, TURKEY ISLAND, STE. GENEVIEVE REACH, AND LIBERTY REACH.

STE. GENEVIEVE, MO., *June 30, 1896.*

MAJOR: I have the honor to submit the following report of operations for the improvement of the Mississippi River between Michael and Bishop landings during the fiscal year ending June 30, 1896:

The various works will be considered in the order of their locations downstream. The position of each hurdle and protection mattress, the adjacent shore and bar lines, and the low-water channel conditions, are all shown on the charts of the annual low-water survey which are submitted herewith.

Operations were conducted at one or more places from July to November, inclusive, in the fall, and in the spring season from March to June.

MICHAEL LANDING.

Hurdle No. 1.—This hurdle was thoroughly repaired and strengthened in September to withstand the ice of the winter. Two stone piers were added at the west shore connection, and all the piers were raised to the level of the 20-foot stage. The ice buttresses were raised and strengthened with stone, and heavy mattresses were

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* Plates Nos. 1 and 8 not printed.

made and sunk over the drift which had collected along the entire length of the line. The revetment at Osborne Towhead was also thoroughly repaired.

Hurdle No. 3.—This was extended (July and August) to the channel limit, and in order to close the chute, which at mean and high stages carried a large volume of water behind Perry Towhead, the line for the extension was deflected downstream to the upper end of the towhead. On account of this inclination, which would induce a current along the front of the hurdle, the foundation mattress was widened to 130 feet, and the piling was driven through its center in a single row 1,750 feet long, of 3 and 4 pile clumps, according to the depths encountered, spaced 8 feet centers, unbraced, but wattled to the level of the 20-foot stage. The mattress was carried in both directions around the upper end of the towhead and a stone revetment was laid above it to the top of the bank.

Both hurdles at this locality were broken during the spring high water, the upper by two loaded coal barges which went adrift in the tornado of May 27. These breaks will be repaired as soon as the water has fallen.

DANBY LANDING.

The revetment of the Missouri shore from this place to the head of the chute between Rush and Lee islands was begun with the force brought from Michael Landing on the completion of that work.

The mattress, 4,750 feet in length, was placed September 18 to October 31, 1895, and the stone revetment between the mattress and the foot of the abrupt bank at about the contour of a 15-foot stage was finished November 15.

Portable jetty.—At the beginning of the low-water season in September the bar at Danby Landing developed into one of the worst shoals in this section of the river, and threatened to become a very serious obstruction to navigation. To correct this a movable jetty was placed here in the early part of October, and was retained in position until November 16, contracting the cross section and cutting a good navigable channel, which was in use during the fall season. The details of this work are given at the end of this report.

BRUCE ISLAND.

A force which had been engaged in bank protection near Liberty Island was brought to this place October 30 and raised the stone revetment from the 6-foot contour, at which it had been left in the fall of 1894, to the 12-foot contour to which the bank had been graded by the action of the July high water. This work for the entire length (3,350 feet) of the protection was completed November 13, and the force was removed for similar duty to Turkey Island.

CROOKS LANDING.

This series of hurdles was begun August 3 with the construction of lines Nos. 1 and 2 of the project. On account of shoal water it was impossible to carry either of these hurdles quite to its full length or to begin any others below them. Therefore, to reenforce the head of the series, two short, strong lines, Nos. 0 and —1, with ice buttresses and heavy stone shore revetments, were built above No. 1, and both were fully completed. All four hurdles are in the usual form, with foundation mattresses 100 feet wide, through which the piling was driven in double lines of 4-pile clumps, screened with brush curtains to the level of the 15-foot stage, the only modification being the lowering on an even slope of the tops of the piling in the outer 500 feet of each line from the 25-foot level to the 15-foot level.

Work on this series was suspended October 19, and the force was removed to Turkey Island and Ste. Genevieve.

TURKEY ISLAND.

The protection mattress begun in June, 1895, was extended 1,800 feet during July, when its construction was suspended that the force might be used on the construction of the hurdles at Crooks Landing, as a favorable stage of water then prevailed for the latter work. On the completion of these hurdles the mattress was resumed, and at the close of the fall season it had been carried downstream 2,600 feet farther, as far as was then necessary.

The total length of the mattress is 5,250 feet, and above it the stone revetment has been carried on the natural slope of the bank to the 15-foot contour for 2,500 feet at the upper end of the work, dropping to the 8-foot contour in the next 750 feet, and to the 5-foot contour for the remaining 2,000 feet. After the present high water this revetment should be raised as far as the slope will permit.

Work was completed November 21.

STE. GENEVIEVE REACH.

Work on the series of hurdles on both sides of the river in this reach was continued throughout the year, and resulted in the virtual completion of Hurdles Nos. 2, 3, 4, 6, 8, 10, 12, 15, 16, 17, 18½, 20, and 22 and the Missouri series of Hurdles Nos. 2, 3, 4, 7, 8, 10 and the partial completion of Nos. 5, 6, 12, 14, and 15.

ILLINOIS SERIES.

Hurdles Nos. 2, 3, and 4 (built in 1891), although they had collected large deposits, had been badly broken by ice. They were restored to their full lengths and strengthened by redriving the piling through the old mattresses and by placing pile buttresses at their outer ends. This new work was not wattled, however, on account of fear of scour in the deposit over the mattresses, and because from their positions at the head of the series these hurdles are particularly likely to collect drift which will serve in its place.

Hurdles Nos. 6, 8, 10, and 12 were all entirely completed with curtains to the 10-foot stage and with heavy ice buttresses at their river ends. As No. 12 was much exposed, it was strengthened with three additional buttresses and by bracing for 300 feet on its outer end. Heavy mattresses were built and sunk over the drift collected during high water on all these lines, for their full lengths on Nos. 6, 8, and 12 and across the deep water on No. 10.

Hurdle No. 15 (across Moro Chute) was completed in the fall, but was broken during the high water in December. The gap, 125 feet in width, was repaired in the spring, and the hurdle has suffered no further damage, but the Illinois bank during the high water of May and June was cut away at the hurdle end, necessitating its protection and the extension of the line, both of which are now in progress.

Hurdles Nos. 16 and 17 were begun August 22. They were completed in the fall with curtains and ice buttresses. As with the hurdles at Crooks Landing, the tops of these lines slope from the 25-foot level to the 15-foot in the outer 500 feet of their lengths. The upper line (No. 16) was also braced for its entire length, and was strengthened on its upper side with a thick drift mattress and ballast of spalls.

The shore ends of both lines, which abutted against a high sand bar partially covered with willows, were heavily revetted with mattresses and stone to the top of the bank.

During the almost unprecedented high water in December this bar was cut away for 250 feet, and in the spring both hurdles were extended that distance, and afterwards were carried to the bank of Moro Island, though in a lighter form.

Hurdle No. 18½.—During the high water in May a considerable volume of water was carried off through the cut between Moro Towheads. To check this a light hurdle 500 feet long was built between the towheads, consisting of a mattress 60 feet wide with a row of single piles spaced 8-foot centers, on which brush screens to the level of a 25-foot stage were supported.

Hurdles Nos. 20 and 22.—Both were built in the spring season and were entirely completed. No. 20 was broken by a part of the coal fleet which broke the Michael Landing hurdles, but the break was repaired, and the whole line was strengthened by sinking the drift collected along its front.

MISSOURI SERIES.

Hurdles Nos. 2 and 3.—These were entirely completed in the fall, except that curtains were not placed, as so much drift collected above these lines as to render it unnecessary. The drift, however, was sunk, heavily reenforcing the piling.

Hurdles Nos. 4, 5, and 6 were about one-half completed in the fall, being carried to the middle bar as far as was possible at the stage of water prevailing, although in the first-named the mattress was then completed to the end of the line, and the piling was driven across it in May. No further extension on Nos. 5 or 6 was made.

Near the shore ends of these hurdles across the deep water the piling was braced, and curtains to the 10-foot stage were placed along the entire length of piling driven in the fall.

Hurdles Nos. 7 and 8 were both entirely completed in November and curtained for their full lengths. As the outer end of No. 7 rested against a willow bar, no buttress was necessary. Two, however, were driven above No. 8, as its outer end was much exposed. The latter line was braced for its full length, the former only across the deep water near shore.

Hurdles Nos. 9, 10, and 11 were only begun in the fall. The shore protection mattresses were then placed, and the piling was driven across them and braced. Curtains were hung above the piling, and on No. 11 about 150 feet of foundation mattress was extended beyond the the shore protection. No. 10 was pushed to completion in the spring, and drift collected there was sunk along its full length.

As the current seemed to have left the Missouri shore between Hurdles Nos. 10 and 14, it was decided to build at present only the alternate lines, Nos. 12 and 14, and to defer further work on Nos. 9 and 11.

Hurdles Nos. 12, 14, and 15, begun in the spring, are almost entirely completed.

In the Missouri series the shore ends of Nos. 2, 3, 4, 5, 8, 9, 10, and 12 were graded with a pile driver jet and revetted to the 20-foot contour. On Nos. 6 and 7 the stone was carried only to the foot of the abrupt bank at the 16 and 12 foot contours, respectively.

LIBERTY REACH.

The protection of the Missouri bank between Anchor and Bishop landings was rendered imperative because of its recent rapid erosion at all except very low stages of river.

The old detached revetment, parallel with the shore and only about 100 yards out from it, held a large stream of water against the softer main bank, which rapidly cut it away.

Work was begun July 3. The mattress was completed October 5 and the stone revetment at the close of that month.

This protection was placed in three sections, as local necessity demanded, and is 7,250 feet in total length. The upper section, 1,800 feet, is just above Anchor Landing, and is separated from the remainder by a space of 900 feet, which is occupied by a very shoal gravel bar over which it seemed unnecessary to lay a mattress.

The remainder, 5,450 feet, is continuous, although it was placed in two sections, the lower section, 2,900 feet, being placed first, as the stage of the water was then favorable.

The stonework was carried above the mattresses for its entire length to the 16-foot contour, no grading being attempted, the stone used for this purpose being obtained from the old detached revetment, which was completely stripped down to the water edge at a 3-foot stage. It is hoped that the sand bank thus left will be carried away by the present high water.

The new revetment must be raised as soon as the bank above it, which is very soft and easily eroded, has been graded by the action of the river.

SURVEYS.

During the low-water season (October and November) a survey was made of the entire reach from Michael Landing to Red Rock, the charts of which are submitted, as has been mentioned.

AUXILIARY WORKS.

Portable jetties.—In the early part of October the jetty outfit was assembled for use at Danby Crossing. The river at this place was 2,200 feet in width, and flowed slowly over a submerged bar broken by reefs, under none of which could more than 4 feet in depth be found. The steamboat channel at the time crossed the upper reef almost at right angles with the axis of the river into the deep water next the Missouri shore. The location chosen for the jetty was just below the channel and in a straight line from the crest of the reef 300 feet from the Missouri bank as far toward the Illinois bar as might be thought necessary to produce the desired contraction in the cross section.

The jetty, being thus at right angles with the banks and wholly detached from them, did not in any way act as a training wall for the current, although under other circumstances that might be the most desirable way in which it could be used.

Placing the jetty was begun October 7. A row of piles 20 feet apart (two piles per flat) was driven 1,200 feet in length from the 4-foot depth near the west bank to the 10-foot depth in midriver. Above these piles and lashed to them the flats were placed in a continuous row and the steel gates were hung over their upper sides, resting at a considerable angle against the flats and the river bottom, thus allowing for their straightening up as the bottom scoured, the upper ends of the angles being lashed back to the flats.

This jetty, 1,200 feet in length, was built in four days with a force of 22 men, including the crews of the pile driver, derrick, and small steam tender used to tow the plant into position.

The effect was almost immediate. There being left only 300 feet and 700 feet in clear waterway past the ends of the jetty, scour began at once, and although in the west channel over the shoalest bar there was, contrary to all expectations, a rapid silting up, so that it was soon impassable for boats even of the smallest class, yet the scour took place in the narrow side channel between the small upper bars and the foot of Perry Towhead. This channel deepened rapidly to 7 feet, widening also,

except at its extreme lower end, where it persistently remained narrow and crooked. Nevertheless it was much used by single steamers in both directions.

The channel east of the jetty straightened downstream and deepened steadily, until at the close of the season 7 feet depth was also had with sufficient width for single steamers, and 6 feet was obtained wide enough for tows, although the river had fallen from 3.5 feet to 2.5 feet on the gauge. On October 25 the Light-House Establishment lighted and marked this channel, which remained the principal channel in the vicinity during the rest of the low-water season.

Along the whole length of the jetty a considerable scour was effected, extending from 5 feet above the aprons to the same distance below the flats and from 4 to 6 feet in depth, the eroded material being deposited in the shadow of the jetty in a ridge parallel with it, and also over the extensive shoal below which is shown on the chart submitted.

Soon after the aprons were placed a towboat collided with the jetty near its west end and a number of the aprons were badly bent. Several more were crippled through buckling and bending of the soft angle bars under side strain. These were all repaired and strengthened with oak pieces 3 by 6 inches by 16 feet laid inside the angles and bolted to them.

Very few of the pile supports were scoured out, and when replaced in no instance did they again require attention.

At the close of the season (November 16 to 23) the jetty was removed, as it was unsafe to risk the plant being caught in the ice, which after that date might be expected to run. All of the gates were recovered and all of the piles were drawn whole, loaded on barges, and were used in the spring.

Table of work done during the fiscal year ending June 30, 1896.

	Michael Landing.		Danby Landing.		Bruce Island, bank protection.	Crooks Landing.				Turkey Island, bank protection.
	Hurdle No. 1.	Hurdle No. 3.	Jetty.	Bank protection.		Hurdle No.—1.	Hurdle No. 0.	Hurdle No. 1.	Hurdle No. 2.	
Lengths of work projected, feet	3,000	1,750	1,200	10,000	3,350	450	690	850	1,200	5,250
Equivalent lengths built, feet	1,000	1,750	1,200	4,750	450	450	690	850	1,200	4,050
Piles driven ..... number	.....	1,025	118	.....	.....	527	794	705	938	.....
Piles driven, penetration, feet	.....	18,923	2,235	.....	.....	9,634	14,083	12,239	15,795	.....
Foundation mattress fabricated and sunk, linear feet	.....	2,650	.....	.....	.....	900	960	1,000	1,050	.....
Foundation mattress fabricated and sunk, square feet	.....	318,600	.....	.....	.....	94,710	99,100	109,530	107,840	.....
Drift mattress fabricated and sunk.....linear feet	3,442	60	.....	.....	.....	.....	.....	688	.....	.....
Drift mattress fabricated and sunk....square feet	134,992	1,500	.....	.....	.....	.....	.....	20,005	.....	.....
Protection mattress fabricated and sunk, linear feet	.....	.....	.....	4,750	.....	.....	.....	.....	.....	4,400
Protection mattress fabricated and sunk, square feet	.....	.....	.....	610,675	.....	.....	.....	.....	.....	558,925
Curtains placed, linear ft	.....	2,500	.....	.....	.....	400	610	700	1,050	.....
Curtains placed. square ft	.....	21,100	.....	.....	.....	5,460	7,900	7,650	8,985	.....
Stone revetment placed, linear feet	1,100	700	.....	4,750	3,350	250	130	130	100	5,500
Stone revetment placed, square feet	28,550	12,200	.....	158,950	74,050	6,000	900	900	500	187,860
Grading.....linear feet	.....	.....	.....	240	.....	.....	.....	.....	.....	.....
Grading.....square feet	.....	.....	.....	1,555	.....	.....	.....	.....	.....	.....
Buttresses built ..number	.....	.....	.....	.....	.....	1	1	.....	.....	.....
Buttresses repaired...do	8	.....	.....	.....	.....	.....	.....	.....	.....	.....

Table of work done during the fiscal year ending June 30, 1896—Continued.

	Ste. Genevieve, Ill.						
	Hurdle No. 2.	Hurdle No. 3.	Hurdle No. 4.	Hurdle No. 6.	Hurdle No. 8.	Hurdle No. 10.	Hurdle No. 12.
Lengths of work projected.....feet..	1,500	1,400	950	725	875	1,075	1,550
Equivalent lengths built.....do....	200	275	80	100	175	35	400
Piles driven.....number..	427	565	164	15	10	240	393
Piles driven, penetration.....feet..	7,417	10,577	2,919	291	187	4,653	5,888
Braces placed.....number..	.....	.....	.....	.....	.....	.....	84
Drift mattress fabricated and sunk, linear feet.....	.....	.....	.....	625	870	180	2,195
Drift mattress fabricated and sunk, square feet.....	.....	.....	.....	15,625	26,700	5,400	56,325
Curtains placed.....linear feet..	.....	.....	.....	.....	.....	.....	380
Curtains placed.....square feet..	.....	.....	.....	.....	.....	.....	7,660
Buttresses built.....number..	1	1	1	.....	.....	.....	3
Buttresses repaired.....do....	.....	.....	.....	1	1	1	1

	Ste. Genevieve, Ill.					
	Hurdle No. 15.	Hurdle No. 16.	Hurdle No. 17.	Hurdle No. 18½.	Hurdle No. 20.	Hurdle No. 22.
Lengths of work projected.....feet..	1,300	1,000	1,750	500	1,850	1,050
Equivalent lengths built.....do....	500	1,000	1,750	500	1,850	1,050
Piles driven.....number..	282	1,153	1,114	106	1,444	764
Piles driven, penetration.....feet..	5,045	20,193	19,698	2,042	26,439	13,076
Braces placed.....number..	.....	123	.....	.....	.....	.....
Foundation mattress fabricated and sunk.....linear feet..	700	1,860	2,222	532	2,068	1,226
Foundation mattress fabricated and sunk.....square feet..	85,600	207,525	243,025	31,920	206,800	135,000
Drift mattress fabricated and sunk, linear feet.....	1,115	875	.....	1,975	1,975	.....
Drift mattress fabricated and sunk, square feet.....	43,750	26,250	.....	54,990	54,990	.....
Curtains placed.....linear feet..	175	755	1,370	520	1,450	530
Curtains placed.....square feet..	2,625	10,735	13,855	5,200	33,110	10,600
Stone revetment placed.....linear feet..	300	.....	350	.....	150	310
Stone revetment placed.....square feet..	7,500	.....	6,150	.....	3,200	6,820
Grading.....linear feet..	.....	.....	.....	.....	.....	310
Grading.....square feet..	.....	.....	.....	.....	.....	1,515
Buttresses built.....number..	.....	1	1	.....	1	.....

	Moro Island, bank protection.	Ste. Genevieve, Mo.				
		Hurdle No. 2.	Hurdle No. 3.	Hurdle No. 4.	Hurdle No. 5.	Hurdle No. 6.
Lengths of work projected.....feet..	5,700	1,000	1,300	1,600	1,575	1,500
Equivalent lengths built.....do....	90	650	550	1,600	850	1,000
Piles driven.....number..	.....	1,063	1,048	1,352	920	890
Piles driven, penetration.....feet..	.....	17,628	16,982	22,990	15,574	15,162
Braces placed.....number..	.....	.....	.....	.....	99	87
Foundation mattress fabricated and sunk.....linear feet..	.....	.....	.....	1,800	1,030	1,450
Foundation mattress fabricated and sunk.....square feet..	.....	.....	.....	200,450	104,800	139,200
Drift mattress fabricated and sunk, linear feet.....	.....	350	1,080	.....	.....	.....
Drift mattress fabricated and sunk, square feet.....	.....	8,750	27,375	.....	.....	.....
Curtains placed.....linear feet..	.....	.....	.....	680	770	710
Curtains placed.....square feet..	.....	.....	.....	11,200	7,575	8,150
Stone revetment placed.....linear feet..	1,540	.....	300	600	300	150
Stone revetment placed.....square feet..	15,400	.....	3,600	8,890	13,500	2,550
Grading.....linear feet..	.....	.....	.....	300	280	.....
Grading.....square feet..	.....	.....	.....	1,400	1,165	.....

Table of work done during the fiscal year ending June 30, 1896—Continued.

	Ste. Genevieve, Mo.					
	Hurdle No. 7.	Hurdle No. 8.	Hurdle No. 9.	Hurdle No. 10.	Hurdle No. 11.	Hurdle No. 12.
Lengths of work projected.....feet..	1,150	1,200	1,000	1,300	1,850	2,450
Equivalent lengths built.....do....	1,150	1,200	100	1,300	250	2,450
Piles driven.....number..	1,085	1,632	95	1,395	108	2,469
Piles driven, penetration.....feet..	19,079	27,642	1,566	24,091	1,980	41,452
Braces placed.....number..	64	293	17	79	.....	.....
Foundation mattress fabricated and sunk.....linear feet..	1,300	1,420	300	1,760	450	2,965
Foundation mattress fabricated and sunk.....square feet..	142,500	154,000	30,000	198,300	52,750	312,400
Drift mattress fabricated and sunk, linear feet.....	.....	.....	.....	1,590	.....	.....
Drift mattress fabricated and sunk, square feet.....	.....	.....	.....	47,320	.....	.....
Curtains placed.....linear feet..	1,075	1,140	.....	225	70	.....
Curtains placed.....square feet..	9,840	17,350	.....	4,050	1,140	.....
Stone revetment placed.....linear feet..	385	100	300	300	.....	.....
Stone revetment placed.....square feet..	12,120	3,000	15,000	17,125	.....	.....
Grading.....linear feet..	316	57	300	185	.....	.....
Grading.....square feet..	1,862	211	2,380	329	.....	.....
Buttresses built.....number..	.....	2	.....	.....	.....	.....

	Ste. Genevieve, Mo.		Ste. Genevieve, dredging.	Liberty Reach, bank protection.	Total.
	Hurdle No. 14.	Hurdle No. 15.			
Lengths of work projected.....feet..	2,900	2,900	.....	9,350	.....
Equivalent lengths built.....do....	2,100	2,400	.....	9,350	.....
Piles driven.....number..	1,477	1,810	99	.....	26,227
Piles driven, penetration.....feet..	25,590	30,814	1,661	.....	453,545
Braces placed.....number..	.....	.....	.....	.....	846
Foundation mattress fabricated and sunk, linear feet.....	2,847	3,251	.....	.....	33,741
Foundation mattress fabricated and sunk, square feet.....	289,450	307,775	.....	.....	3,571,275
Drift mattress fabricated and sunk, linear feet.	.....	.....	.....	.....	15,045
Drift mattress fabricated and sunk, square feet.	.....	.....	.....	.....	468,982
Protection mattress fabricated and sunk, linear feet.....	.....	.....	.....	7,250	16,400
Protection mattress fabricated and sunk, square feet.....	.....	.....	.....	1,112,900	2,282,500
Curtains placed.....linear feet..	.....	674	.....	.....	15,784
Curtains placed.....square feet..	.....	10,110	.....	.....	204,295
Stone revetment placed.....linear feet..	.....	.....	.....	7,250	28,345
Stone revetment placed.....square feet..	.....	.....	.....	107,145	691,910
Grading.....linear feet..	.....	.....	.....	.....	1,988
Grading.....square feet..	.....	.....	.....	.....	10,417
Buttresses built.....number..	.....	.....	.....	.....	13
Buttresses repaired.....do....	.....	.....	.....	.....	12

Very respectfully, your obedient servant,

WM. S. MITCHELL, *Assistant Engineer.*

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

REPORT OF MR. GERALD BAGNALL, ASSISTANT ENGINEER, ON WORKS AT HORSETAIL BAR, WEST; TWIN HOLLOWS, WEST; SULPHUR SPRINGS, FOSTER ISLAND, LUCAS, CORNICE ISLAND, AND LIBERTY, MO.

LIBERTY, MO., *June 30, 1896.*

MAJOR: I have the honor to make the following report of operations between the mouth of the Missouri River and Michaels Landing and at Liberty, Mo., during the fiscal year ending June 30, 1896.

Work was carried on at the following localities between the mouth of the Missouri River and Michaels Landing: Horsetail Bar, west; Twin Hollows, west; Sulphur Springs, Foster Island, Lucas, Cornice Island, and Liberty, Mo.

At Horsetail bar, west, work was commenced on October 21, 1895, and suspended for the season on November 14. At Twin Hollows, west, work was commenced on July 5, 1895, and suspended on August 2. At Sulphur Springs work was commenced on July 15, 1895, and suspended on July 20, and resumed on October 4, when it was continued until November 19.

The delays in the prosecution of the work at Sulphur Springs were due principally to the necessity of gradually crowding out the steamboat channel so as not to interfere with navigation.

At Foster Island work was commenced on October 22, 1895, and suspended on November 2. Work was continued at Lucas until October 19, 1895, when operations were suspended. On November 14 work was resumed and continued until November 24, the close of the season of 1895. Work was again resumed at this locality on March 14, 1896, and continued until April 11. Work was continued at Cornice Island until August 6, 1895, when it was finished as far as the stage of river would admit.

Work was commenced at Liberty, Mo., on April 3, 1896, and continued until the end of the fiscal year.

WORK DONE.

Horsetail Bar, west.—The revetment was carried up to the foot of the bluff bank, or about 14 feet above standard low water, for a distance 1,500 feet below Dike No. 1.

Twin Hollows, west.—Two pieces of bank-protection mattress were constructed at this locality, and the bank above them partially revetted. Their aggregate length was 2,120 linear feet. (See pl. No. 2.)

Sulphur Springs.—Hurdles 13, 14, 15, and 15½ were completed and buttresses built at the outer ends. These were carried to a 20-foot stage, and were constructed of brush and stone. Hurdle No. 13 was double clumped, and 180 feet of the outer end braced diagonally. Hurdle No. 14 was braced diagonally for 300 feet from the outer end and then double clumped for 280 feet farther. Hurdle No. 15 was double clumped and 265 feet of the outer end braced. Hurdle No. 15½ was double clumped and braced for 220 feet from the outer end. The revetment on the shore ends of hurdles Nos. 14, 15, and 18 was carried up the bank to a 22-foot stage. (See pl. No. 3.)

Lucas.—Hurdles Nos. 0 to 11 were built out to the projection. Hurdles Nos. 13 and 15 could not be completed on account of the low stage of river. Buttresses were constructed on Hurdles Nos. 0, 2½, 3¼, 3½, 4½, 5½, 6, and 7. That on Hurdle No. 0 was carried up to a 20-foot stage; the others to about a 10-foot stage, except on Hurdle No. 2½, where it was built to a 12-foot stage. Hurdles Nos. 0, 0½, 2½, 4½, and 7 were double clumped; also 500 feet at the outer end of Hurdle No. 1½, 130 feet at the outer end of Hurdle No. 3¼, 150 feet on the outer end of No. 3½, 220 feet on the outer end of No. 5½, 175 feet on the outer end of Hurdle No. 6, 300 feet on the outer end of Hurdle No. 9, and 1,025 feet on the inner end of No. 11.

On Hurdle No. 11 the low stage of river prevented the double clumping of the outer end. Hurdle No. 0 was also braced diagonally as well as double clumped, and 80 feet on Hurdle No. 1½ was braced. Hurdle No. 15 could not be completed into the high bank on account of the low stage of river. Hurdle No. 2½ was protected by two extra pile buttresses in the fall of 1895 on account of its exposed position, the two hurdles immediately above it not having been then completed out to the projection. The shore ends of all the hurdles were protected by revetment carried back to the willows. (See pl. No. 3.)

Foster Island.—The bank protection was carried up to about 11 feet above standard low water for a distance of 800 feet from the head of the shore-protection mattress. (See pl. No. 3).

Cornice Island.—During the fiscal year Hurdles Nos. 1, 2, and 4 were completed, Hurdle No. 1 was double clumped for 130 feet from the outer end, Hurdle No. 2 was double clumped for its entire length, Hurdle No. 3 was double clumped for 400 feet from the outer end, Hurdle No. 4 was double clumped for 560 feet from the outer end, and Hurdle No. 5 was double clumped for 200 feet from the outer end. The shore ends of all the hurdles were revetted. Buttresses were constructed on Hurdles Nos. 1, 2, and 4. Those on Nos. 2 and 4 were built to 22-foot stage, and on Hurdle No. 1 to a 14-foot stage. The low stage of river prevented the construction of a hurdle across chute behind Cornice Island. A quantity of drift was sunk on Hurdle No. 1. (See pl. No. 3.)

Liberty, Mo.—Hurdles Nos. 1, 2, 3, 4, 5, 7, and 10 were completed, except 400 feet on the outer end of No. 10 and some revetment on Hurdles Nos. 5 and 10. Hurdles from No. 1 to No. 7 were double clumped from the outer end for distances as follows: Hurdles No. 1, 720 feet; No. 2, 870 feet; No. 4, 200 feet; No. 5, 1,540 feet; No. 7, 2,750 feet. Hurdle No. 10 was double clumped for 990 feet from the inner end and for 450 feet from the towhead out.

Hurdle No. 1 was braced diagonally for 425 feet from the outer end, No. 3 for 300 feet from the outer end, No. 5 for 285 feet from the outer end, and No. 7 for 300 feet from the outer end. (See pl. No. 6.)

METHOD OF CONSTRUCTION.

The general methods of construction, which were the same as during the previous years, are shown in sketches on file in the United States engineer office, St. Louis, Mo. First-class piles were used as far as practicable on the outer ends of the hurdles.

COST OF WORK.

The cost of the work per linear foot at Sulphur Springs and Lucas was above the average, owing to those works being but extensions of the old hurdle systems, and consequently often entailing a proportionally excessive amount of protection work at the ends as compared with the lengths of the hurdles. It was also increased by the fact that it was necessary to build many of the hurdles slowly on account of encroaching on the steamboat channels, thus necessitating repeated suspensions of work.

RESULTS, OBSERVATIONS, AND REMARKS.

The continued low water prevailing during the spring of 1895 prevented the obtaining of as great results as might otherwise have been expected. A sudden rise of the river in December, 1895, caused a large deposit at all localities where hurdles had been constructed. Owing to the low stage of river in the spring and summer of 1895, the amount of work that could be done between St. Louis and Michaels Landing was so small that it was found necessary to reduce the force, and therefore toward the end of August nearly one-half of those employed on this reach were transferred to Mr. William S. Mitchell, assistant engineer.

A good navigable channel was maintained throughout the low-water season between St. Louis and Michaels Landing.

SURVEYS.

A low-water survey was made between Eads Bridge and Michaels Landing, a tracing of which, showing comparative soundings of that survey with the low-water survey of 1894, was transmitted with the semiannual report for the half year ending December 31, 1895.

TABLES.

The following tables accompany this report:

Table No. 1, showing work done at Horsetail Bar, west, Twin Hollows, and at Foster Island during the fiscal year ending June 30, 1896.

Table No. 2, showing the work done at Sulphur Springs during the fiscal year ending June 30, 1896.

Table No. 3, showing work done at Lucas during the fiscal year ending June 30, 1896.

Table No. 4, showing work done at Cornice Island during the fiscal year ending June 30, 1896.

Table No. 5, showing work done at Liberty, Mo., during the fiscal year ending June 30, 1896.

Table No. 6, showing summary and distribution of work done and money expended for labor during the fiscal year ending June 30, 1896.

BANK PROTECTION.

TABLE NO. 1.—*Work done during fiscal year ending June 30, 1896.*

	Horse-tail Bar, west.	Twin Hollows, west.	Foster Island.	Total.
Piles driven ..... number..	.....	65	.....	65
Mattress constructed and sunk ..... linear feet...	.....	2,120	.....	2,120
Mattress constructed and sunk ..... square feet..	.....	254,400	.....	254,400
Linear feet completed	.....	2,120	.....	2,120
Revetment ..... square feet..	45,000	30,000	33,660	108,660

TABLE NO. 2.—*Work done at Sulphur Springs during the fiscal year ending June 30, 1896.*

	At Hurdle No.—						Total.
	13.	14.	15.	15½.	17.	18.	
Hurdle constructed ..... linear feet..	210	810	700	460	.....	.....	2,180
Hurdle rebuilt ..... do....	.....	.....	60	110	.....	.....	170
Hurdle braced ..... do....	180	300	265	220	85	.....	1,050
Hurdle strengthened ..... do....	760	280	730	220	85	.....	2,075
Foundation mattress constructed and sunk ..... do....	300	997	840	636	.....	.....	2,773
Foundation mattress constructed and sunk ..... square feet..	33,000	103,300	87,600	67,200	.....	.....	291,700
Buttress constructed ..... cubic yards..	2,054	1,226	2,000	1,815	.....	.....	7,095
Curtain constructed ..... square feet..	16,780	17,920	22,070	.....	.....	.....	56,770
Revetment at end of hurdles ..... do....	.....	3,500	4,000	.....	.....	3,080	10,580
Excavation ..... cubic yards..	.....	500	600	.....	.....	.....	1,100
Piles driven ..... number..	484	632	634	443	46	.....	2,239
Braces placed ..... do....	36	66	36	40	12	.....	190

TABLE NO. 3.—*Work done at Lucas during the fiscal year ending June 30, 1896.*

	At Hurdle No.—						
	0.	0½.	1½.	2½.	3¼.	3½.	4½.
Hurdle constructed..linear feet..	500	865	895	640	360	460	400
Hurdle rebuilt.....do....	50	40	.....	.....	.....	.....	.....
Hurdle braced.....do....	400	130	70	.....	.....	.....	.....
Hurdle strengthened.....do....	500	725	500	640	130	150	400
Foundation mattress.....do....	1,000	1,395	1,478	1,285	904	830	490
Foundation mattress constructed and sunk.....square feet..	101,860	143,100	151,240	134,740	98,008	85,600	52,000
Mattress ballasted.....do....	.....	.....	.....	9,000	.....	.....	.....
Buttress constructed, cubic yards.....	1,328	.....	.....	3,666	921	897	731
Curtain constructed.square feet..	11,156	21,904	25,050	.....	7,554	9,922	8,580
Revetment at end of hurdles, square feet.....	12,290	72,200	42,253	25,048	5,951	24,400	29,091
Excavation.....cubic yards..	700	.....	1,220	.....	.....	.....	.....
Piles driven.....number..	651	828	720	745	266	362	453
Braces placed.....do....	88	26	9	.....	.....	.....	.....
Stringers placed.....do....	.....	.....	.....	1	.....	.....	.....

	At Hurdle No.—							Total.
	5½.	6.	7.	9.	11.	13.	15.	
Hurdle constructed .linear feet..	350	470	670	920	1,140	640	1,020	9,330
Hurdle rebuilt.....do....	.....	.....	.....	.....	.....	.....	.....	90
Hurdle braced.....do....	.....	.....	.....	.....	.....	.....	.....	600
Hurdle strengthened.....do....	220	175	670	300	1,025	.....	.....	5,435
Foundation mattress.....do...	732	745	927	1,225	915	980	1,555	14,461
Foundation mattress constructed and sunk.....square feet..	76,800	78,100	96,300	126,100	95,100	97,000	155,500	1,491,448
Shore mattress constructed and ballasted.....square feet..	.....	.....	.....	5,400	.....	.....	.....	5,400
Mattress ballasted.....do....	5,000	.....	4,600	9,306	.....	.....	.....	27,906
Buttress constructed, cubic yards.....	733	717	1,703	.....	.....	.....	.....	10,696
Curtain constructed, square feet.....	7,938	8,140	13,530	10,080	15,460	8,450	.....	147,764
Revetment at end of hurdles, square feet.....	30,458	20,003	19,224	9,315	13,456	9,292	.....	312,981
Excavation.....cubic yards..	.....	.....	.....	.....	2,000	.....	.....	3,920
Piles driven.....number..	290	354	576	626	1,050	351	553	7,825
Braces placed.....do....	.....	.....	.....	.....	.....	.....	.....	123
Stringers placed.....do....	.....	.....	.....	.....	.....	.....	.....	1

TABLE NO. 4.—*Work done at Cornice Island during the fiscal year ending June 30, 1896.*

	At Hurdle No.—					Total.
	1.	2.	3.	4.	5.	
Hurdle constructed.....linear feet..	225	175	.....	95	.....	495
Hurdle strengthened.....do...	130	675	400	560	200	1,965
Drift mattress constructed and ballasted, dimensions.	175 x 72 x 3	.....	.....	.....	.....	175 x 72 x 3
	175 x 82 x 2	.....	.....	.....	.....	175 x 82 x 2
	165 x 85 x 2	.....	.....	.....	.....	165 x 85 x 2
Buttress constructed.....cubic yards..	3,905	2,574	.....	411	.....	6,890
Curtain constructed.....square feet..	.....	13,210	12,940	12,320	4,320	42,790
Revetment at end of hurdle.....do..	24,520	14,017	14,000	15,000	7,005	64,542
Excavation.....cubic yards..	.....	.....	2,000	3,000	3,900	8,900
Piles driven.....number..	229	360	123	247	22	981

TABLE NO. 5.—*Work done at Liberty during fiscal year ending June 30, 1896.*

	At Hurdle No.—							Total.
	1.	2.	3.	4.	5.	7.	10.	
Hurdle constructed..linear feet..	780	870	1,010	1,150	1,540	2,830	2,870	11,050
Hurdle braced.....do...	425	.....	300	.....	285	300	.....	1,310
Hurdle strengthened.....do...	720	870	.....	200	1,540	2,750	1,440	7,520
Foundation mattress constructed and sunk.	linear feet..	1,195	1,304	1,474	1,645	2,045	3,635	3,705	15,003
	square feet..	121,900	132,800	149,800	171,820	211,940	374,360	374,100	1,536,720
Curtain constructed, square feet..	.....	16,318	17,060	7,040	34,475	18,036	28,342	121,271
Revetment at end of hurdles.do...	23,732	22,699	15,000	14,000	10,372	14,996	65,220	166,019
Excavation.....cubic yards..	200	1,800	2,500	2,925	4,028	.....	300	11,753
Piles driven.....number..	739	809	597	639	1,437	2,575	1,894	8,690
Braces placed.....do...	70	.....	58	.....	57	64	.....	249
Penetration.....feet..	12,179	13,606	10,296	10,903	24,860	44,588	32,920	149,352

TABLE NO. 6.—*Summary and distribution of work done and money expended during the fiscal year ending June 30, 1896.*

Total cost by pay rolls: Hurdles, $80,702.99; bank protection, $3,404.34; St. Genevieve, $36; total, $84,143.33.

Total work done: Hurdle constructed, 23,055 linear feet; hurdle rebuilt, 260 linear feet; 24,681 cubic yards of buttress at a cost of $5,233.53. Bank protection mattress, 2,120 linear feet; 254,400 square feet; revetment, 108,660 square feet.

Work done at Horsetail Bar, Missouri: Revetment, 45,000 square feet.

Work done at Twin Hollows, Missouri: Mattress, 2,120 linear feet; 254,400 square feet; revetment, 30,000 square feet.

Work done at East Sulphur Springs: Hurdle constructed, 2,180 linear feet; hurdle rebuilt, 170 linear feet; 7,095 cubic yards of buttress at a cost by pay roll of $1,486.39.

Work done at Foster Island, Illinois: Revetment, 33,660 square feet.

Work done at Lucas, Ill.: Hurdle constructed, 9,330 linear feet; hurdle rebuilt, 90 linear feet; 10,696 cubic yards of buttress at a cost by pay rolls of $2,302.75.

Work done at Cornice Island: Hurdle constructed, 495 linear feet; 6,890 cubic yards of buttress at a cost by pay rolls of $1,444.39.

Work done at Liberty, Mo.: Hurdle constructed, 11,050 linear feet.

Very respectfully, your obedient servant,

GERALD BAGNALL, *Assistant Engineer.*

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

REPORT OF MR. E. D. LIBBY, ASSISTANT ENGINEER, ON PROCURING BRUSH AND STONE FOR THE CONSTRUCTION OF WORKS OF IMPROVEMENT.

STE. GENEVIEVE, MO., *June 30, 1896.*

MAJOR: I have the honor to submit the following report of operations for procuring brush and stone during the fiscal year ending June 30, 1896:

PROCURING BRUSH.

At the beginning of the year the work of procuring brush was in progress by a single party at Twin Hollows, west.

A second party was organized and put in the field on July 25, and on August 13 a third party was put to work.

The brush parties are referred to here as Nos. 1, 2, and 3, corresponding to dates and order of organization.

Brush party No. 1 remained at Twin Hollows until July 14, and was then moved to East Sulphur, where a small quantity of brush was obtained, after which the force was moved to the foot of Fosters Island, remaining at Fosters Island and vicinity until August 6th. It was then taken into the old river a short distance above St. Marys, and on August 13 it was moved to Fairy Island, but the rapidly falling river made it necessary to move from this locality. This was done on the 16th of August, the party being taken to the foot of Kaskaskia Island and from thence on the 22d of August it was moved to Baumgaertens Island. The procuring of brush at this locality was completed on October 16 and the party was moved to Calico Island, where work was carried on until November 11, when field operations closed for the season.

For the spring season of 1896 this force (No. 1) was organized and put in the field on March 2, the first work being at Kaskaskia Island, near Dalassus Landing. Work at this point was carried on until March 12, when the party was moved upstream about 1½ miles to the Illinois shore, near Bonnets Ferry. Here the party remained until March 31 and was then moved to Moro Island and the procuring of brush was carried on until April 25, when it was taken to Bald Bar. At this locality work was continued until May 12, and then the party was moved to Scudders Towhead, and at this place and vicinity it remained until the close of the fiscal year.

Quarter boat No 1 and derrick boat No. 1 were in service with this party during the time that field operations were in progress.

Brush force No. 2 commenced work on a towhead in the old river above St. Marys on July 25, remaining in this vicinity until August 16. It was then moved to the foot of Kaskaskia Island, where the work was continued until the disbanding of the force on November 14.

This party was reorganized and put in the field on March 4, 1896, being located at the foot of Kaskaskia Island at the same point where work was in progress at the time of closing for the season of 1895.

On account of the high water in May work on Kaskaskia Island ceased on May 22,

and the party was moved to the Illinois shore, a short distance above Chester. Here one barge load of brush was obtained, and then the force was moved into the slough between Cranes and Pricketts Island. From this locality it was moved to the outside of Cranes Island on June 2, and on July 11 it was moved to Turkey Island. Work at this and various other localities was carried on until the close of the year.

At Kaskaskia Island much of the brush was obtained only by a very long haul. The greatest number of teams employed by this party at any one time was 49.

Since leaving Kaskaskia the moving of the party has been frequent on account of the small quantity of brush found at each locality.

Quarter boat No. 10 and derrick boat No. 2 were in service with this party while field operations were in progress.

Brush force No. 3 commenced work at Pulltight on August 13, and during the time it was in the field procured brush from Pulltight, Beards Island and vicinity, and from Jim Smiths. This force was disbanded on October 17.

For the use of this party, quarter barges were employed and a pile driver was fitted up for temporary use as a derrick boat.

During the year there were procured 71,976.8 cords of brush.

PROCURING STONE.

At the beginning of the year work at the quarry was in progress with a force of about 100 men.

During the month of July, all of the work done was at the lower quarry, where most of the drilling and the loading could be done by steam. As the season advanced and the demand for stone increased, it became necessary to divide the force, so as to permit loading at more than one locality.

The low stage of the river was especially favorable for loading by barrows at several points along the ledge.

On August 24 a pile driver was received, the boiler of which was utilized in furnishing steam to run the drills at points inconvenient of access by steam pipes from the boiler at the lower quarry. By this arrangement much of the drilling was done by steam for those gangs which loaded by barrows.

Two steam drills were in service at the beginning of the year. On July 8 a new steam drill was received and put in service, and on October 14 two more were added to the outfit. All of these were in constant use until the close of the work in 1895, except when laid off for occasional repairs.

Whenever practicable all drilling was done by steam. Hand drilling was employed only for block holing and for drilling at points where the ledge was bad or could not be reached by steam pipes.

During the year 31,695 linear feet of holes were driven by steam drills and 11,270 linear feet by hand drills.

On July 13 a pile-driver pump was put in service and was employed at different times during the year in clearing the earth from the top of the ledge, and proved much more economical than hand labor.

Quarter boat No. 10 was in service until July 25 and was then transferred to the brush force. After this date the shore quarters were employed for the accommodation of the men at the quarry. Additional quarters were set up in the latter part of September to meet requirements due to an increase of the force.

In September a steam derrick was fitted up and early in October was put in service for loading stone at the upper quarry.

Work with the full force was continued during the fall season until November 21.

From this date until March a small force was employed in quarrying and breaking stone and in clearing earth from the top of the ledge.

On the 11th of March active work for the spring season was commenced at the lower quarry, where operations were carried on almost exclusively until the close of the fiscal year. The force of laborers was first increased on March 20, and from this time on such additions were made to the force as the demand for stone required.

Three steam drills were in constant service during active operations in the spring.

A pile driver was received on March 17, the boiler of which was used for providing steam for one of the steam drills.

With the exception of loading two barges of stone, no work was done at the upper quarry during the spring season.

The maximum number of men employed at any time during the year was 243, which was early in October.

During the year there were procured 97,612.6 cubic yards of stone, 31,695 linear feet of drilling was done by steam drills, and 11,270 linear feet by hand drills, 27,475 cubic yards of earth and spalls removed.

Very respectfully, your obedient servant,

E. D. LIBBY,
Assistant Engineer.

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

REPORT OF MR. JOHN O. HOLMAN, ASSISTANT ENGINEER, ON CHANGE OF GAUGE RELATIONS AT MEDIUM AND LOW STAGES RESULTING FROM CONTRACTION WORKS.

ST. LOUIS, MO., *June 30, 1896.*

MAJOR: I have the honor to submit herewith the following report on the change of slope at medium and low stages between St. Louis and Cornice Rock since 1891, resulting from the construction of hurdles or contraction works.

The report is based on the annual low-water survey, gauge readings, reports of hurdles constructed, and reports of channel crossings by steamboat pilots. Mean depths and areas derived from the survey are plotted in profile on pl. 1; the data obtained from the other sources are appended to the report in tabulated form.

Gauges were established at Jefferson Barracks, Waters Point, and Cornice Rock in September, 1891. As their records show a change of 3 feet in low-water plane at Waters Point, it is necessary to mention the reliability of the gauges and the accuracy of the readings. The gauges were made of strap iron, 3 by one-fourth inch, fitted close to the rocky ledge which crops out from the Missouri bank at these points and fastened to the rock by bolts at irregular intervals. The high water portion of the Barracks gauge, reading from 26 to 40, the only section of these gauges not fastened to solid rock, was placed after the high water of 1892, and the lowest section, 1.9 to —0.1, in 1894. The readings at Waters Point in 1894 and a part of 1895 were taken on a temporary gauge set by levels on a pile driven for the purpose close to the permanent gauge, but this section, 6.2 to 2.0, was reset November, 1895, on a portion of the ledge not covered by a deposit during high stages. The gauge at Cornice remains the same as originally placed. The zeros of these gauges were connected by closed lines of levels to the nearest bench of the Mississippi River Commission line of precise levels. The present gauge at St. Louis was first read in December, 1873. Its description is given in the Report of the Chief of Engineers for 1874, page 488.

The datum used by this office is 200 feet below the St. Louis Directrix. The elevation of the gauge zeros above this datum are as follows: Jefferson Barracks, 163.97; Waters Point, 156.70; Cornice Rock, 152.35, and St Louis, as determined by the Mississippi River Commission levels, 166.26.

All gauge readings were plotted on a comparative hydrograph, erroneous ones corrected or discarded, and doubtful ones avoided as much as possible in selecting readings for Table 3, which gives the actual elevation of the water surface above the office datum at medium and low stages. Those selected are at the crest of a slow swell or the bottom of a decline, and in nearly stationary periods the average of two or three days is used in preference to a single reading. The gauge readings corresponding to the low elevations of this table are:

	1891.	1892.	1893.	1894.	1895.
St. Louis	4.40	3.50	3.13	3.00	2.30
Jefferson Barracks	4.43	3.43	2.73	2.00	1.05
Waters Point	4.40	3.78	4.00	4.50	4.00
Cornice Rock	4.55	3.55	2.43	2.40	1.05

The 4-foot stage on the St. Louis gauge was adopted in 1881 as the standard low water. When the new gauges were established, their zeros were placed 4 feet below this stage, so that a 4-foot reading, or standard low water at St. Louis, would give the same reading on the other gauges. Reducing the Waters Point readings in the above table to 4 feet, and the others accordingly, gives this 4-foot stage for 1891 and shows the yearly change in the low-water plane, which in 1895 amounts to 3 feet at Waters Point.

	1891.	1892.	1893.	1894.	1895.
St. Louis	4.00	3.72	3.13	2.50	2.30
Jefferson Barracks	4.03	3.65	2.73	1.50	1.05
Waters Point	4.00	4.00	4.00	4.00	4.00
Cornice Rock	4.15	3.77	2.43	1.90	1.05

The gauge readings corresponding to the medium stage, the highest elevations given in Table 3, are:

	1892.	1893.	1894.	1895.
St. Louis	17.00	17.60	17.70	17.10
Jefferson Barracks	15.25	15.65	16.30	16.30
Waters Point	15.70	16.40	17.20	17.50
Cornice Rock	15.10	15.10	15.80	15.50

and their reduction to the 17-foot stage at St. Louis gives:

	1892.	1893.	1894.	1895.
St. Louis	17.00	17.00	17.00	17.00
Jefferson Barracks	15.25	15.05	15.60	16.20
Waters Point	15.70	15.80	16.50	17.40
Cornice Rock	15.10	14.50	15.10	15.40

showing a decided change in this stage, although not as large as in the low. With the St. Louis gauge reading 17 feet, the Waters Point gauge has changed from a reading of 15.70 in 1892 to one of 17.40 in 1895, a foot less than the extreme change in the low stage for the same period. Plate 2 is a comparative profile of these stages with the medium at 17 feet on the St. Louis, and the low at 4 on the Waters Point, gauge.

Table 4 gives the fall and slope from gauge to gauge derived from the elevations of Table 3, in which the low-water channel measurement of 1895, see Table 1, was used for the distance between the gauges for both stages. Between St. Louis and the Barracks the slope at medium stage has decreased, while the low shows a regular increase; from the Barracks to Waters Point both slopes have decreased, and from Waters Point to Cornice both have been increasing.

Table 5 is also derived from Table 3 by assuming the elevations of November 21, 1895, the second day of five successive readings of 2.3 on the St. Louis gauge, as the elevation of that stage on all the gauges. The table readily shows the oscillation of 1895 produced by the same difference in the discharge of the river, as the low reading is 2.3 on all the gauges, while the high varies from 15.80 at Waters Point to 17.55 at the Barracks. Deducting the low of each year from the high gives the oscillation of that year; their differences show the change from year to year.

	Oscillation from low to medium stage.				Difference in—				Total.
	1892.	1893.	1894.	1895.	1892.	1893.	1894.	1895.	
St. Louis	13.50	14.47	14.70	14.80					
					1.68	1.55	0.40	—0.45	2.13
Jefferson Barracks	11.82	12.92	14.30	15.25					
					— .10	.52	1.60	1.75	1.85
Waters Point	11.92	12.40	12.70	13.50					
					— .37	.27	.70	.95	1.32
Cornice Rock	11.55	12.67	13.40	14.45					

The difference column shows 1.68 more oscillation at St. Louis in 1892 than at the Barracks, and 0.45 less in 1895, a total change of 2.13 in the four years. The increase at the other gauges is not as large, but the change has been uniform between consecutive gauges. Comparing Jefferson Barracks with the others, the increase is 2.13 more than at St. Louis, 1.85 more than at Waters Point, and 0.53 more than at Cornice; compared with the St. Louis gauge the increase is 2.13 more at the Barracks, 0.28 more at Waters Point, and 1.60 more at Cornice. The change in the oscillation is noticeable in pl. 2, where the low stages gradually separate from the 17-foot stage at St. Louis, and the medium from the 4-foot stage at Waters Point.

The channel depths on the bars were obtained from the reports of the pilots to their associations and from the weekly reports of the boats in this department. Any single measurement reported by the pilots can not be considered accurate, except at very shoal crossings, where extra soundings are taken to find a depth sufficient for the passage of the boat or barges. Arsenal Island, the first crossing below St. Louis, was reported during a nearly stationary period as having a depth of 6½ feet November 1, 1895, 8 on the 2d, 4½ and 6 on the 4th, and 6 and 7 on the 5th; yet the average of these depths well represent the condition of the crossing. Table 6 gives the number of soundings and the average depth reported on the crossings during September, October, and November of each year, now on file in this office; Table 7, the average monthly readings during this period on the four gauges, and as the fluctuation of the river during October and November of these years (see Table 2) exceeded 2 feet only in October, 1891, the average reading and channel depth for these months not only give the general condition of the crossing, but also a close approximation for any special day.

In Table 8 the average October channel crossings are placed between the proper gauges, but arranged in the order of least depth, with the average October slope given for each year. Arsenal Island is the only crossing from St. Louis to the Barracks,

and its depth has become less. Pulltight, the shoalest crossing in the next stretch during 1891 and 1892, has deepened, and Carroll Island, about 2 miles above, is now the shoal crossing. From Waters Point to Cornice in 1891 there were four crossings of about the same depth, but in all other instances the shoalest crossing is a foot or more less in depth than the others in that stretch.

Table 9 is a short description of the six series of hurdles or contraction works from St. Louis to Cornice, built since 1891, giving the lengths of hurdles, dates of construction, the length of each series, and its average length of hurdle, which is the reduction in the width of the river.

A hydrographic survey was made during the low-water season of 1892–1895; from the Barracks in 1892, the Eads Bridge in 1893 and 1895, and from the River Des Peres in 1894. Soundings at intervals of about 100 feet were taken on cross-section lines which averaged 5 to the mile. Tables of the depth, interpolated when necessary, for each 100 feet in length, the distance of the sounding line from the Eads Bridge on the low water channel of 1895, the stage of the adjoining gauges, and the mean depth and area derived from the soundings have been placed on file. These results are platted on pl. 1, showing the stage of the river at which the soundings were taken by a slope line between the gauges, the profile of mean depth platted from a horizontal in preference to a slope line, which is known only as a straight line between the gauges and the profile of area. Under the profiles is a map of the river during the low-water season of 1895, on a scale of 1 to 100,000.

The contraction work of 1893 was at Carroll Island, Pulltight, and Twin Hollows in both working seasons of the calendar year, but the extent of the first series, both in length and reduction in the width of the river, was much smaller than the others, which were on opposite sides of the river, and have a combined length of 4 miles, with a reduction, or length of hurdle, varying from 165 to 1,400 feet. The Pulltight crossing, with an October depth of 4.9 and 4.6 feet in the years 1891 and 1892, deepened to 9.9 feet in 1893. Pl. 1 locates this shoal at mile 17.4, with a mean depth of 6.6 feet, and an area of 16,000 square feet, less than any above it for the year 1892, but about equal to the mean depth and area just above Waters Point at mile 21. As Pulltight offered the resistance to flow, the slope of 1892 above mile 17 was the same in all probability as the slope for some distance above the Barracks. The ratio of fall between mile 17 and Waters Point, Table 4, is $4.83 - 10.94 \times 7.30 = 3.22$; but figured on the assumption that the slope was uniform from St. Louis to mile 17, the fall would be $6.06 \times 0.22 = 1.33$ from the Barracks to mile 17, and 7.30 minus 1.33, or 5.97 from there to Waters Point. This fall gives a slope of 1.24 feet per mile, which, though excessive, is not larger than the low-water slope along the upper front of the city between the Chain of Rocks and Bissells Point.

The assumed slope of 1.24 below mile 17 is approximate only, but it is probably nearer to the actual slope of 1892 between those points than the slope of 0.67 derived from the gauge readings. It illustrates the obstruction to flow at Pulltight before the construction of the Twin Hollows and Pulltight hurdles, and if slope is the measure of resistance to flow, now generally recognized as its function in the discharge of rivers, the reduced slope in this reach is the result of a larger low water cross-section area and a greater mean depth produced by the hurdles. The survey of 1893 between the Barracks and the foot of these works was made at a much higher stage than in 1892. In 1894 the profile lines of mean depth and area on pl. 1, between mile 17 and 18, are greater than in 1892, even with a foot higher stage on the slope line in the profile above; but if the mean depths are platted under the assumed slope line of 1892, and the one for 1894, which is certainly not a straight line between the gauges, although a much nearer approach to one than in 1892, the result would somewhat show the actual change in the mean elevation of the bottom of the river for those years. It would increase the change shown in the profile of mean depths by the difference in the assumed fall from there to Waters Point, 5.97 less 3.22, and would show a deeper mean elevation of the bottom above mile 17, whereas the profile now shows the mean depth to average about the same for both years. The area above mile 17 is larger in 1892, but the stage of water was higher and at least 2 feet more than shown by the survey slope line. The surveys were made to show the general condition of the works, the changes in the channel, and the location of the bars obstructing low-water navigation; their aid in determining the effect of hurdle construction would be much greater were they accompanied by low-water discharge observations and actual water elevations at frequent intervals.

The object and immediate result of hurdle construction is the removal of obstructing bars, as the hurdles offer no resistance at low water, except when built at low stages into the channel; the removal of the bars by the contraction during medium and high stages produces a larger cross-section area at low water, the resistance to flow becomes less, and the head necessary for the discharge is reduced. The large increase in area resulting from the Pulltight hurdles lowered the low-water plane at the Barracks gauge in 1893 and 1894, and more in the latter year when the fill under the hurdles added to the reduction in medium stage area. The slope in the stretch

above was increased by this change at the Barracks gauge, but the decrease in slope from there to Waters Point was undoubtedly aided by the peculiar condition of the river at mile 21.

At this point on pl. 1 the mean depth and area for 1892, 1894, and 1895 are about the same for the same stage at Waters Point. At miles 19 and 20 there are high points in the profile lines, but none of both lines for the same year as at mile 21. The years 1894 and 1895 were noted for their minimum rainfall. The discharge was probably less in those years than in 1892, yet the Waters Point gauge remained at about the same reading during the low-water months of October and November. The only change in the gauge relation for 1892 was at this point. The increase in slope between this point and Cornice continued during 1893 and 1894, and in 1895, when the works at Sulphur Springs, Lucas, and Cornice Island were constructed, the yearly increase was somewhat larger than before.

A reduction of slope followed the construction of hurdles in the middle reach, while in the lower the construction was followed by an increase between the gauges. The Pulltight works changed the area at the point of resistance, the reduction of slope extended to the gauge above, and the gauges, though farther from the contracted portion than in the lower reach, showed the reduced slope. The hurdles at Sulphur Springs did not enlarge the area nor increase the mean depth above mile 23 (see pl. 1), and therefore effected but little change at mile 21, which certainly controls the reading on the Waters Point gauge.

The medium stage slopes do not show clearly the effect of the different series, as the gauges are too far from the limits of the contraction to register the immediate result. The change of slope between the Barracks and Waters Point arising from the considerable reduction of area at Pulltight in 1893 was certainly modified by the high stage of that year and complicated in 1894 and 1895 by the construction of hurdles at Carroll Island just above the Barracks, and also by the three series below Waters Point. The resistance to flow offered by the Pulltight hurdles probably produced the decreased slope above the Barracks (see Table 4); the decreased slope in 1895 above Waters Point and the increase below may be due to the hurdles at Sulphur Springs and Lucas, but the latter is doubtful as the change in the lower stretch was as large before the works were built. The combined effect of the six series, however, is apparent from the higher medium stage plane since 1893 at the lower gauges (see pl. 2), and it is the only evidence of the change resulting from the hurdles that can be obtained from the medium stage readings.

The change in the low-water relation of the gauges at Bissells Point and St. Louis following the construction of the hurdles between the bridges is a good illustration of the influence of a contracted river on the low-water slope, because of the near location of the gauges. Twelve hurdles, with an average length of 1,130 feet, reduced the width of the river in 1891 to 1,700 feet at the upper and 2,200 at the lower end of the work. Distances above the St. Louis gauge are as follows:

	Miles.		Miles.
Bissells Point	3.7	Lower hurdle	1.3
Merchants' Bridge	3.6	Eads Bridge	0.4
Upper hurdle	3.4	St. Louis gauge	0.0

The combined water width through the three spans of the Eads Bridge is 1,525 feet and somewhat less than that at the Merchants'.

Gauge readings and elevations.

Date.	Bissells Point.		St. Louis.		Fall.	Highest reading at St. Louis.
	Reading.	Elevation.	Reading.	Elevation.		
1888.						
October 7–8	73.8	173.32	5.7	171.96	1.36	29.3
October 23–25	73.5	173.02	5.3	171.56	1.46	
1889.						
October 15–16	72.2	171.72	3.6	160.86	1.86	24.4
November 27–30	73.6	173.12	5.0	171.26	1.86	
1890.						
December 17–18	71.4	170.92	3.0	169.26	1.66	20.7
December 25–27	72.3	171.82	4.0	170.26	1.56	
1891.						
October 6–9	72.2	171.72	4.0	170.26	1.46	23.5
October 27–28	73.3	172.82	5.1	171.36	1.46	

Gauge readings and elevations—Continued.

Date.	Bissells Point.		St. Louis.		Fall.	Highest reading at St. Louis.
	Reading.	Elevation.	Reading.	Elevation.		
1892.						
October 23–25	72.0	171.52	5.0	171.26	.26	36.0
November 10–11	72.1	171.62	5.0	171.26	.36	
1893.						
September 2–4	72.1	171.62	5.1	171.36	.26	31.5
October 13–15	71.2	170.72	4.1	170.36	.36	
1894.						
September 6–7	71.5	171.02	3.8	170.06	.96	23.5
September 23	72.8	172.32	5.1	171.36	.96	
1895.						
September 22	73.3	172.82	5.2	171.46	1.36	17.1
October 14–15	71.9	171.42	3.9	170.16	1.26	

The Bissells Point gauge is on the inlet tower of the city waterworks, and its position has not been disturbed since 1880, when the Mississippi River Commission line of precise levels found the 89-foot mark (St. Louis directrix, 100.0) 0.48 too low.

The slopes derived from the above table vary from 0.5 in 1889 to 0.1 in 1892 and 1893. The piers and east approach of the Merchants Bridge, built in 1890, reduced the slope that year, and the hurdles reduced it again in 1891. But the resistance to flow during the flood of 1892 produced a slope of 1.04 feet per mile when at its maximum; its energy created a deeper bed, which at low water became a pool, with very little resistance to the flow at the 5-foot stage; hence the very low slope of 0.1 for that year. The highest reading for each year is given in the above table to show the peculiar relation of the fall between the gauges and the high reading on the St. Louis gauge.

Plate 1 shows the difference in the contracted portions of the lower harbor. The mean depth and area are much less in 1895 than in 1893, except in the wider parts at the foot and for 2 miles above the head of Arsenal Island. If the flood height of 1892 produced the larger area and the fill resulted from the following low stages, the survey of 1896, if made at the usual low stage, should show areas larger than in 1895 to correspond with the higher stages of this year. A width of 2,500 feet has been adopted for the improved river below St. Louis. Along the city the width is much less, ranging from 1,500 at the bridges and the lower end of the harbor, 2,000 at Arsenal Island and below the Eads Bridge, to widths of 3,000 feet above and below Arsenal Island. This general contraction of the river has resulted in a small low-water slope through the harbor, joined to large ones above and below. A gauge was established at the Chain of Rocks, 7 miles above Bissells Point, by the city water department in 1892. The slope of that year was 1.13 from there to Bissells Point, 0.1 to St. Louis, 0.23 to the Barracks, and 0.67 to Waters Point.

Whether the water surface has been lowered at St. Louis for the same discharge during these years can not be determined, as only one discharge measurement was taken, but a comparison with the measurements of 1880 shows a lowered surface:

Date.	Stage.	Area.	Width.	Velocity.	Discharge.
November 13, 1880	8.2	30,738	1,506	2.31	95,722
December 14, 1880	5.4	29,940	1,920	1.71	51,240
October 25, 1895	2.7	22,040	1,855	2.20	48,000

The first is an average of eight measurements near St. Louis during November 2–13, taken from the Annual Report of the Chief of Engineers for the year 1883, page 2257. The gauge at St. Louis was nearly stationary, with an average reading of 8.2 for the period. The others are single measurements by this office, that of 1880 at the city, and the one of 1895, 18 miles below. An increase of 0.8 on the gauge in 1895 or a reading of 3.5 on the St. Louis gauge would nearly produce the discharge of December, 1880, which was taken at the 5.4-foot stage.

Levels of 1880 and 1888 give the following slopes to points near the Barracks, with the gauge at the 12 and 14 foot stages: 1880, 0.53; 1888, 0.30; 1895, 0.20 foot per mile. The difference of 0.33 in the slope represents 3.6 feet less fall between St. Louis and the Barracks in 1895 than in 1880, or 1.7 more than the surface was lowered by the comparison of discharges.

TABLE NO. 1.—*Distances measured in the low-water channel of 1895.*

Locality.	Miles.	Locality.	Miles.
Eads Bridge	0.0	Kimmswick	21.5
St. Louis gauge	0.42	Waters Point gauge	21.77
United States Engineer Depot	3.1	Sulphur Springs:	
Arsenal Island:		Head	21.9
Head	4.2	Upper hurdle	22.4
Foot	6.0	Sunnyside	23.0
River Des Peres	8.1	Sulphur Springs	23.5
Dike No. 1	8.9	Glen Park	24.7
Horsetail, upper hurdle	9.6	Foster Island, head	25.1
Jefferson Barracks	10.4	Sulphur Springs, lower hurdle	25.2
Horsetail, lower hurdle	10.7	Bushberg	25.9
Jefferson Barracks gauge	10.83	Lucas, upper hurdle	27.5
Quarantine	11.9	Foster Island, foot	27.6
Carroll Island:		Herculanæum	28.8
Head	12.0	Joachim Creek	29.1
Upper hurdle	12.3	Joachim Bluff, head	29.5
Lower hurdle	12.8	Lucas, lower hurdle, and Calico Island, head.	30.6
Foot and Twin Hollows, head	13.1	Platin Rock	30.7
Twin Hollows, upper hurdle	14.3	Cornice Island:	
Pulltight, upper hurdle	15.2	Upper hurdle	31.2
Twin Hollows, lower hurdle	16.0	Head	31.5
Whitehouse	17.2	Lower hurdle	32.0
Pulltight, lower hurdle	18.3	Cornice Rock gauge	32.08
Fines Bluff, foot	18.5	Cornice Island, foot	32.1
Jim Smiths, head	18.8		
Meramec River	19.3		
Chesley Island:			
Head	19.3		
Foot	20.8		

TABLE NO. 2.—*St. Louis gauge, highest and lowest reading of each month.*

Month.	1891.		1892.		1893.		1894.		1895.	
	High.	Low.	High.	Low.	High.	Low.	High.	Low.	High.	Low.
January	5.3	2.9	10.0	3.1	7.5	2.8	4.0	0.6	3.0	—0.7
February	11.5	3.5	17.2	6.7	11.2	8.0	6.4	0.2	6.1	4.3
March	19.3	6.8	18.5	12.0	22.1	12.0	20.1	5.3	8.1	5.0
April	23.4	18.1	26.8	17.4	29.0	15.9	18.7	9.8	9.6	6.1
May	20.6	13.1	36.0	20.2	31.5	22.4	23.3	12.4	9.9	5.6
June	23.0	14.1	34.7	26.2	28.0	17.6	18.3	16.7	12.9	7.1
July	23.5	14.0	31.1	19.2	21.5	10.2	17.0	8.8	17.1	11.7
August	19.8	10.5	18.8	9.5	11.3	5.7	8.8	3.6	13.3	6.1
September	10.1	4.6	9.6	7.0	5.2	3.4	6.1	3.4	10.9	3.5
October	6.4	4.0	6.8	5.0	4.2	3.3	4.0	2.4	4.0	2.6
November	5.7	4.1	6.1	4.4	3.4	2.5	3.4	2.5	2.8	2.2
December	5.6	2.7	5.6	0.3	2.5	0.0	3.7	1.5	23.2	—0.1

NOTE 1.—The low water of 1863 was used for the zero of the gauge and the high of 1826, 33.74 on the present gauge, was taken for the City Directrix. The high of 1892, 36.0, and the low of 1895, —0.7, are the extreme readings on the present gauge.

TABLE NO. 3.—*Water surface at the gauges; elevation above the office datum at medium and low stages.*

	1891.		1892.				
	Oct. 17, 18.	Nov. 4, 5.	Aug. 3–5.	Aug. 16–18.	Aug. 30–Sept. 1.	Oct. 31.	Dec. 5, 6.
St. Louis	172.61	170.66	183.26	179.09	175.79	172.36	169.76
Jefferson Barracks	170.22	168.40	179.22	175.94	173.00	169.87	167.40
Waters Point	162.85	161.10	172.40	168.97	165.82	162.50	160.48
Cornice Rock	158.50	156.90	167.45	164.37	161.28	158.15	155.90

	1893.					
	June 2, 3.	July 22–24.	Aug. 3.	Aug. 14–16.	Oct. 3.	Nov. 17–19.
St. Louis	183.86	180.29	177.56	173.43	169.76	169.39
Jefferson Barracks	179.62	176.90	174.42	170.89	167.07	166.70
Waters Point	173.10	170.37	167.80	164.37	160.95	160.70
Cornice Rock	167.45	164.58	162.10	158.53	155.15	154.78

TABLE NO. 3.—*Water surfaces at the gauges, etc.*—Continued.

	1894.					
	June 9.	June 20–22.	July 24–26.	Sept. 18, 19.	Aug. 30.	Nov. 22.
St. Louis	183.96	182.96	175.76	172.36	169.96	169.26
Jefferson Barracks	*180.27	179.44	172.52	169.22	166.77	165.97
Waters Point	173.90	173.13	166.82	163.85	161.80	161.20
Cornice Rock	168.15	167.45	161.07	157.60	155.50	154.75

	1895.					
	July 8.	June 24.	July 19.	Aug. 22, 23.	Oct. 15.	Nov. 21.
St. Louis	183.36	179.16	177.96	173.46	170.16	168.56
Jefferson Barracks	180.27	176.02	174.57	169.92	166.52	165.02
Waters Point	174.20	170.30	169.00	165.00	162.00	160.70
Cornice Rock	167.85	163.85	162.80	158.30	155.20	153.40

TABLE NO. 4.—*Slope between gauges in feet per mile at medium and low stages.*

	St. Louis to Barracks (10.41 miles).			Barracks to Waters (10.94 miles).			Waters to Cornice (10.31 miles).			Total fall.	
	Fall.	Slope.		Fall.	Slope.		Fall.	Slope.			
		Med.	Low.		Med.	Low.		Med.	Low.	Med.	Low.
1891—Low	2.26	.....	0.22	7.30	.....	0.67	4.20	.....	0.41	.....	13.76
1892—Medium	4.04	0.39	.....	6.82	0.62	.....	4.95	0.48	.....	15.81	.....
Low	2.36	.....	.23	6.92	.....	.63	4.58	.....	.44	.....	13.86
1893—Medium	4.24	.41	.....	6.52	.60	.....	5.65	.55	.....	16.41	.....
Low	2.69	.....	.26	6.00	.....	.55	5.92	.....	.57	.....	14.61
1894—Medium	3.69	.35	.....	6.37	.58	.....	5.75	.56	.....	15.81	.....
Low	3.29	.....	.32	4.77	.....	.44	6.45	.....	.63	.....	14.51
1895—Medium	3.09	.29	.....	6.07	.55	.....	6.35	.62	.....	15.51	.....
Low	3.54	.....	.34	4.32	.....	.39	7.30	.....	.71	.....	15.16

TABLE NO. 5.—*Oscillation between medium and low stages.*

	1891.		1892.				
	Oct. 17.	Nov. 4.	Aug. 4.	Aug. 17.	Aug. 31.	Oct. 31.	Dec. 6.
St. Louis	6.35	4.40	17.00	12.83	9.53	6.10	3.50
Jefferson Barracks	7.50	5.68	16.50	13.22	10.28	7.15	4.68
Waters Point	4.45	2.70	14.00	10.57	7.42	4.10	2.08
Cornice Rock	7.40	5.80	16.35	13.27	10.18	7.05	4.80

	1893.					
	June 3.	July 23.	Aug. 3.	Aug. 15.	Oct. 3.	Nov. 18.
St. Louis	17.60	14.03	11.30	7.17	3.50	3.13
Jefferson Barracks	16.90	14.18	11.70	8.17	4.35	3.98
Waters Point	14.70	11.97	9.40	5.97	2.55	2.30
Cornice Rock	16.35	13.48	11.00	7.43	4.05	3.68

	1894.					
	June 9.	June 21.	July 25.	Sept. 18.	Aug. 30.	Nov. 22.
St. Louis	17.70	16.70	9.50	6.10	3.70	3.00
Jefferson Barracks	17.55	16.72	9.80	6.50	4.05	3.25
Waters Point	15.50	14.73	8.42	5.45	3.40	2.80
Cornice Rock	17.05	16.35	9.97	6.50	4.40	3.65

TABLE NO. 5.—*Oscillation between medium and low stages*—Continued.

	1895.					
	July 8.	June 24.	July 19.	Aug. 22.	Oct. 15.	Nov. 21.
St. Louis	17.10	12.90	11.70	7.20	3.90	2.30
Jefferson Barracks	17.55	13.30	11.85	7.20	3.80	2.30
Waters Point	15.80	11.90	10.60	6.60	3.60	2.30
Cornice Rock	16.75	12.75	11.70	7.20	4.10	2.30

TABLE NO. 6.—*Channel crossings; average monthly depths during low-water period.*

Locality.	September.		October.		November.		Mean.	
	Number of soundings.	Average depth.	Number of soundings.	Average depth.	Number of soundings.	Average depth.	Number of soundings.	Average depth.
1891.		*Feet.*		*Feet.*		*Feet.*		*Feet.*
Arsenal Island	13	8.4	13	8.1	8	9.1	34	8.4
Quarantine	3	9.3	2	7.0	.....	.....	5	8.4
Cliff Cave	9	8.6	10	7.7	8	8.3	27	8.2
Pulltight	15	7.1	12	4.9	10	5.8	37	6.0
Jim Smiths	13	9.0	4	7.1	.....	.....	17	8.5
Meramec	11	8.1	12	6.1	10	7.1	33	7.1
Sulphur Springs	3	13.0	3	9.0	.....	.....	6	11.0
Harrisonville	9	8.7	9	6.1	6	8.1	24	7.6
Joachim	11	7.6	9	6.2	5	7.7	25	7.1
Calico Island	15	8.0	7	6.3	5	6.6	27	7.3
Cornice Island	12	8.0	10	6.6	6	6.4	28	7.1
1892.								
Arsenal Island	14	10.2	10	7.7	8	7.3	32	8.7
Twin Hollows	9	6.0	11	6.8	6	7.0	26	6.6
Pulltight	13	6.6	9	4.6	8	8.2	30	5.5
Meramec	9	8.3	2	7.0	6	6.5	17	7.5
Sulphur Springs	7	12.9	2	8.5	.....	.....	9	12.0
Harrisonville	11	9.0	9	7.4	5	7.5	25	8.1
Joachim	6	6.4	5	5.7	.....	.....	11	6.1
Cornice	11	10.0	2	9.0	.....	.....	13	9.8
1893.								
Arsenal Island	7	6.4	9	6.4	7	5.9	23	6.3
Quarantine	6	8.4	8	8.4	7	8.1	21	8.3
Twin Hollows	1	7.0	8	10.0	4	10.6	13	10.0
Pulltight	7	8.2	7	9.9	6	8.1	20	8.8
Meramec	4	8.0	2	8.5	.....	.....	6	8.1
Waters Point	6	6.8	9	6.6	7	6.1	22	6.5
Sulphur Springs	8	4.8	9	4.9	7	5.0	24	4.9
Bushberg	6	9.1	8	9.0	4	8.6	18	8.9
Harrisonville	7	6.8	7	9.0	4	7.3	18	7.8
Joachim	7	6.7	8	6.3	6	6.5	21	6.5
Cornice	4	7.4	8	7.3	6	7.6	18	7.4
1894.								
Arsenal Island	27	8.4	30	6.7	26	6.5	83	7.2
Carroll Island	29	7.2	32	5.1	32	6.0	93	6.0
Sulphur Springs	29	8.4	25	6.7	33	7.0	87	7.4
Harrisonville	26	10.4	28	8.6	33	8.8	87	9.2
Cornice Island	30	6.9	36	5.4	40	5.7	106	6.0
1895.								
Arsenal Island	42	8.4	29	6.0	28	6.2	99	7.2
Carroll Island	43	8.2	31	5.0	32	5.7	106	6.5
Pulltight	35	11.6	22	7.0	22	6.1	79	8.8
Kimmswick	45	9.0	31	6.5	32	5.7	108	7.3
Lucas	27	8.7	21	7.0	29	7.3	77	7.7
Joachim	26	10.5	28	5.8	30	4.8	84	6.9

TABLE NO. 7.—*Gauges, average monthly readings during low-water period.*

Month.	St. Louis.	Barracks.	Waters.	Cornice.
1891.				
September	6.5	6.6	6.4	6.4
October	5.1	5.1	5.0	5.0
November	4.7	4.6	4.7	5.0
1892.				
September	8.3	7.8	7.8	7.8
October	5.6	5.3	5.3	5.3
November	5.1	4.9	4.9	4.9
1893.				
September	4.1	3.6	4.9	3.1
October	3.7	3.3	4.4	2.9
November	3.2	2.8	4.0	2.5
1894.				
September	4.7	3.8	5.9	4.1
October	2.8	1.9	4.2	2.3
November	3.0	2.0	4.4	2.4
1895.				
September	7.2	6.0	8.3	6.2
October	3.4	2.0	4.8	2.3
November	2.5	1.2	4.2	1.2

TABLE NO. 8.—*October averages of channel depth and slope.*

1891.

St. Louis to Barracks.		Barracks to Waters.		Waters to Cornice.	
Slope	0.22	Slope	0.67	Slope	0.42
Arsenal Island	8.1	Pulltight	4.9	Harrisonville	6.1
		Meramec	6.1	Joachim	6.2
		Quarantine	7.0	Calico Island	6.3
		Cliff Cave	7.7	Cornice Island	6.6
				Sulphur Springs	9.0

1892.

Slope	0.25	Slope	0.66	Slope	0.42
Arsenal Island	7.7	Pulltight'	4.6	Joachim	5.7
		Twin Hollows	6.8	Harrisonville	7.4
		Meramec	7.0	Sulphur Springs	8.5
				Cornice Island	9.0

1893.

Slope	0.26	Slope	0.56	Slope	0.57
Arsenal Island	6.4	Waters Point	6.6	Sulphur Springs	4.9
		Quarantine	8.4	Joachim	6.3
		Meramec	8.5	Cornice Island	7.3
		Pulltight	9.9	Bushberg	9.0
		Twin Hollows	10.0	Harrisonville	9.0

1894.

Slope	0.31	Slope	0.45	Slope	0.61
Arsenal Island	6.7	Carroll Island	5.1	Cornice Island	5.4
				Sulphur Springs	6.7
				Harrisonville	8.6

1895.

Slope	0.35	Slope	0.41	Slope	0.66
Arsenal Island	6.0	Carroll Island	5.0	Joachim	5.8
		Waters Point	6.5	Harrisonville	7.0
		Pulltight	7.0		

TABLE NO. 9.—*Contraction works.*

HORSETAIL, EAST.

Hurdle.	May and June, 1894.	Hurdle.	May and June, 1894.
	Feet.		*Feet.*
No. 20½	220	No. 29¼	880
No. 22½	430	No. 30½	670
No. 24½	670	No. 31½	520
No. 27¼	950		

This series is at the lower end of the old Horsetail system. It was built to check the erosion of the newly formed bank and to reduce the width of the river to 2,500 feet. Its length is 1.19 miles, with a width or average length of hurdle of 620 feet.

CARROLL ISLAND.

Hurdle.	July and August, 1893.	May, 1894.
	Feet.	
No. 2	800	280 feet of No. 5 was strengthened with braces, but the length of the hurdle was not increased.
No. 3	670	
No. 4	450	
No. 5	340	

The first contraction work at this locality. Its length from upper to lower hurdle is 0.57 mile; its width of 565 feet, or average length of hurdle, reduces the river width to 2,500 feet.

TWIN HOLLOWS.

Hurdle.	June, 1893.	July to November, 1893.	April, 1894.
	Feet.	*Feet.*	
No. 2½	.....	270	Nos. 2 to 4 were strengthened with braces and drift mattresses.
No. 3	.....	425	
No. 3½	.....	705	
No. 4	.....	650	
No. 4½	.....	425	
No. 5	360	.....	
No. 6	.....	165	
No. 7	.....	260	

This series is at the lower end of the old Twin Hollows system, which with the works at Pulltight reduces the width of the river to 2,500 feet. The length of the new work is 1.17 miles, with an average hurdle length of 408 feet.

PULLTIGHT.

Hurdle.	1893.		1894.	
	April to June.	August to November.	March.	October.
	Feet.	*Feet.*	*Feet.*	
No. 0	.....	490	(*)	Buttresses were placed on Nos. 0, 0½, 1, and 2.
No. 0¼	.....	1,060	.....	
No. 0½	.....	1,400	.....	
No. 1	700	550	.....	
No. 2	1,200	.....	.....	
No. 4	630	.....	.....	
No. 5	1,700	.....	.....	
No. 6	850	650	.....	
No. 7	.....	1,200	.....	
No. 8	.....	975	260	

* Sixty feet of No. 0 was repaired.

This series restored the old hurdles which had become unserviceable, and extended the upper and lower limits of the previous work. It is 3.09 miles in length, with an average reduction of 1,167 feet in the width of the river.

SULPHUR SPRINGS.

Hurdle.	October to November, 1894.	1895.		Hurdle.	October to November, 1894.	1895.	
		April to June.	July, October, and November.			April to June.	July, October, and November.
	Feet.	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*
No. 2½	.....	400	.....	No. 12	.....	1,000	.....
No 5½	.....	420	.....	No. 13	.....	870	210
No. 6½	440	.....	.....	N.. 14	.....	150	810
No. 8	570	.....	.....	No. 15	.....	260	700
No. 8½	640	.....	.....	No. 15½	.....	435	460
No. 10	.....	675	.....	No. 17	.....	700	.....
No. 10½	.....	930	.....				

This series restored the old hurdles to their original lengths and added several new ones to the high willow bar which had formed at the lower end of the reach. The present series is 2.75 miles long, with an average hurdle length of 744 feet.

LUCAS.

Hurdle.	July to October, 1895.	Hurdle.	July to October, 1895.
	Feet.		*Feet.*
No. 0	500	No. 5½	350
No. 0½	435	No. 6	470
No. 1½	425	No. 7	670
No. 2½	640	No. 9	920
No. 3¼	360	No. 11	1,140
No. 3½	460	No. 13	640
No. 4½	400	No. 15	1,020

This series, which is 3.06 miles long, with an average hurdle length of 602 feet, not only restored the old hurdles, but extended the upper and lower limits of the previous work.

CORNICE ISLAND.

Hurdle.	1895.	
	May and June.	July.
	Feet.	*Feet.*
No. 1	180	225
No. 2	540	175
No. 3	635	.....
No. 4	515	95
No. 5	640	.....

This is a new series, 0.74 mile long, with an average hurdle length of 601 feet. This series, and also the lower hurdle of the Lucas series, reduces the river width only to 3,000 feet.

Very respectfully, your obedient servant,

JOHN O. HOLMAN,
Assistant Engineer.

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

REPORT OF MR. C. D. LAMB, SUPERINTENDENT UNITED STATES SUPPLY DEPOT.

ST. LOUIS, MO., *June 30, 1896.*

MAJOR: I have the honor to submit the following report of operations at the supply depot during the fiscal year ending June 30, 1896.

The work done on the plant during the year is divided into four classes—construction, equipping for service, extraordinary repairs, and ordinary repairs, the last item including watching and care of property. Labor was also employed in handling material and supplies of various kinds.

CONSTRUCTION.

Derricks.—The second derrick at the Ste. Genevieve Quarry was built and put into service, being arranged in the same way as No. 1.

Tools and appliances.—Tools of various kinds were constructed as required, including 26 stone boxes and trucks for the quarry, 2 small derricks, together with capstan bars, pikes, blocks, chains, cold chisels, etc.

Boarding outfit.—The tables, benches, and laundry boxes were built to outfit office boats Nos. 3 and 4 and quarter barges Nos. 8 and 9.

EQUIPPING FOR SERVICE.

Steamer Gen. H. L. Abbot.—The tow and dredge boat *Gen. H. L. Abbot* was received at the depot on August 21, 1895, and was at once supplied with her outfit and made ready for service. The most important part of this work consisted in setting up the steam capstans and dredge pumps. The capstans were each double barreled with two 6 by 12 inch cylinders, like those on the *Gen. Casey.* Two were placed on the forecastle and one at each side at the afterends of the boilers.

The pumps were located in the room designed for them forward of the boilers. They are each duplex outside-packed plunger pumps with 20-inch steam and 12-inch water cylinders, and 24-inch stroke.

The boilers of the boat were also covered with split brick, the drums, heater, and steam pipes protected with sectional covering, and the boat was equipped with electric lights and a steam steering gear.

Tenders.—The drums and steam pipes of Tenders Nos. 4, 5, 6, and 7 were protected by sectional covering.

Dredge barge.—Work was begun upon Barge No. 142 in June, with the intention of fitting it for use as a dredge boat. It was pulled out on the ways, the butts and knuckle seams calked, two fore-and-aft bulkheads put in midway between center and sides, and shoes placed in the sides for supply pumps. The barge was then launched, boiler beams and outriggers put in, and guards built on one end ready for machinery.

Barges.—Model Barges Nos. 139 to 150, built under contract by the Interstate Lumber Company, were received between July 22 and September 24. They were all supplied with hatch hoods and iron pumps.

Office and survey boats.—Ice chests were built in position on office and survey boats Nos. 3 and 4, their outfits were placed aboard, and they were sent out for service.

EXTRAORDINARY REPAIRS.

Barges.—Barges Nos. 106, 107, 109, and 112 were pulled out on the ways and extensively repaired during the year.

These repairs consisted in renewing about three-fourths of the top timbers and cocked hats, all of the knuckle and side plank, timber heads, bitts, kevels, chocks, and plank-sheer, and, except No. 112, the renewal of about half the beams and all of the deck. The sides of all were also calked and painted and the holds cleaned and salted.

Pile drivers.—The rebuilding of Pile Driver No. 18 was completed and it was sent out for service in April. One of the hulls built at Cincinnati during 1893 was used for this purpose, with steel leads, hoisting engine, and a duplex jet pump having 9-inch steam cylinders, 5½-inch plungers, and a 12-inch stroke.

The iron leads on Pile Driver No. 23 became unserviceable in November and they were taken down and replaced with wood, yellow pine 8 by 12 inches being used for that purpose.

The eleven contract-built Drivers Nos. 25 to 35 were also in bad condition, and all except No. 29 were pulled out on the ways at the close of the season and remained there during the winter, while No. 29 was docked early in the spring. Their gunwales were drawn together with clamps and rebolted, hulls calked, cabins and machinery repaired, the leads of Nos. 27, 28, and 30 to 35 taken down and replaced with wood, and the cabins and leads painted.

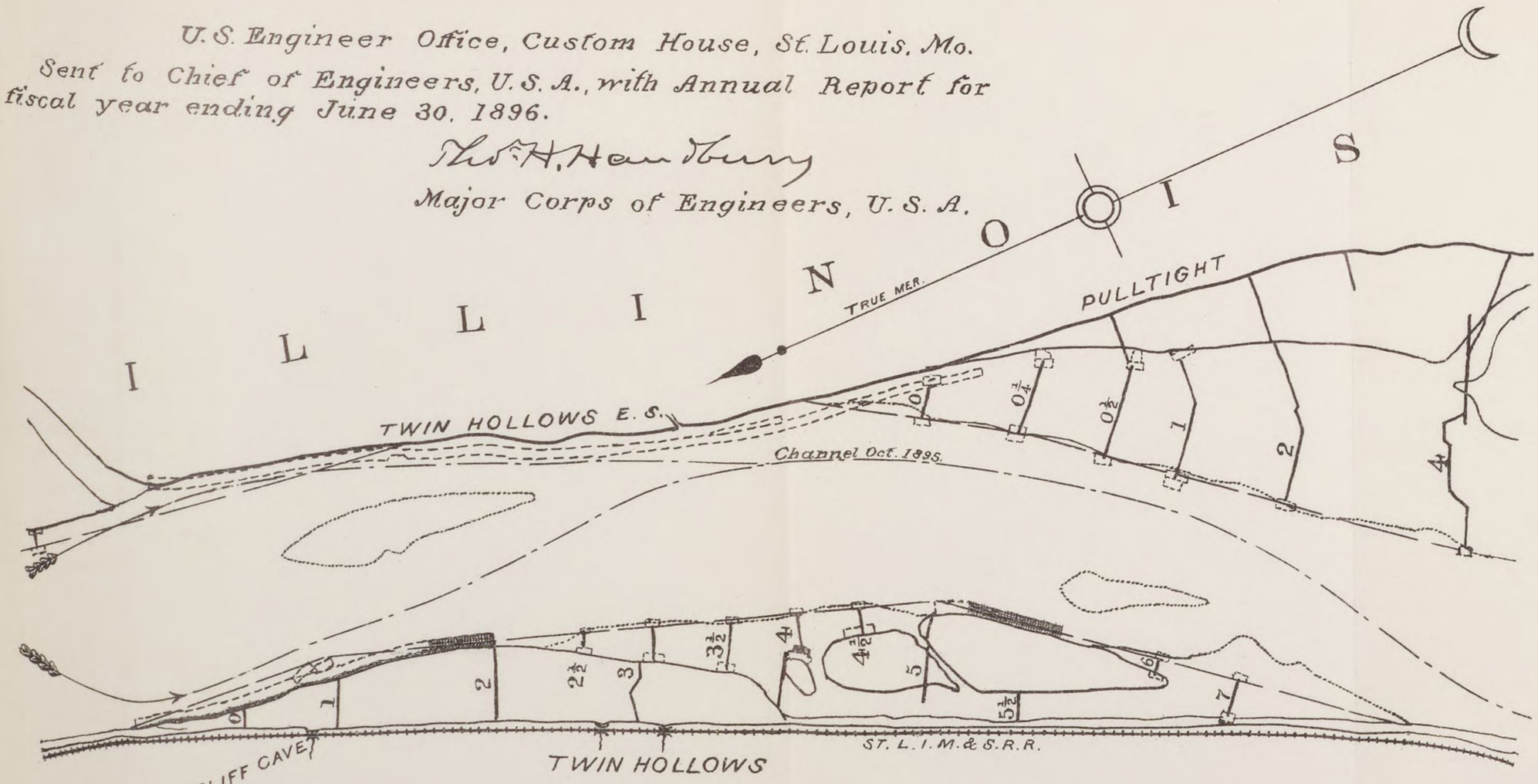
Small boats.—Fifty-four skiffs were rebuilt during the year, new sides being made of California redwood.

ORDINARY REPAIRS.

The top sides and parts of the decks of all the floating plant were calked during the early part of the fall and again in February and March before leaving the winter harbor for the spring season. In addition to the above, repairs were also made upon the plant as follows:

U.S. Engineer Office, Custom House, St. Louis, Mo.
Sent to Chief of Engineers, U.S.A., with Annual Report for fiscal year ending June 30, 1896.

Thos. H. Handbury
Major Corps of Engineers, U.S.A.



MISSISSIPPI RIVER.

MAP SHOWING CONDITION OF WORKS OF IMPROVEMENT AT

TWIN HOLLOWS

June 30, 1896.

SCALE.

1000 500 0 1 2 3 4 5000 6 7 8 9 10000 Ft.

Bars are shown as they appeared during Oct. 1895, at approximate standard low water stage.

Hurdles etc. built during this fiscal year, shown thus — Hurdles. Protection

" " " prior to " " " " " ——— [dashed]

ANDREW B. GRAHAM, PHOTO-LITHO. WASHINGTON, D.C.

MAP SHOWING CONDITION OF WORKS OF IMPROVEMENT

MISSISSIPPI RIVER

TWIN HOLLOWS

SCALE.

July 30, 1888.

U.S. Engineer Office, Custom House,
Memphis, Tenn.

Plate 3.

MISSISSIPPI RIVER.

MAP SHOWING CONDITION OF WORKS OF IMPROVEMENT AT

SULPHUR SPRINGS, LUCAS' & CORNICE ISLAND,

June 30, 1896.

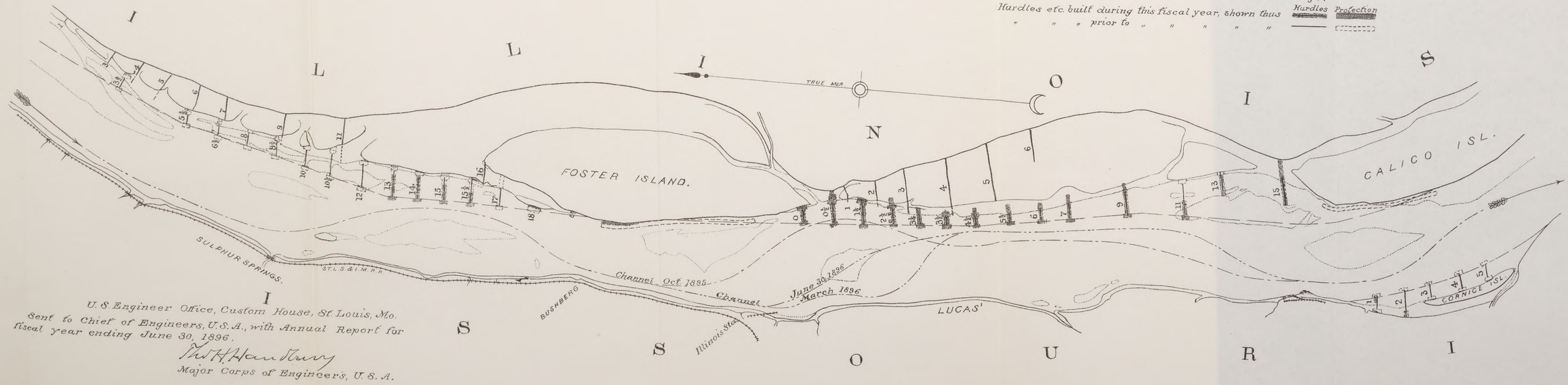
SCALE.

1000 500 0 1 2 3 4 5000 6 7 8 9 10000 Ft.

Bars are shown as they appeared during Aug. Sept. Oct. and Nov. 1895, at approximate standard low water stage.

Hurdles etc. built during this fiscal year, shown thus Hurdles Protection

" " " prior to " " " " "

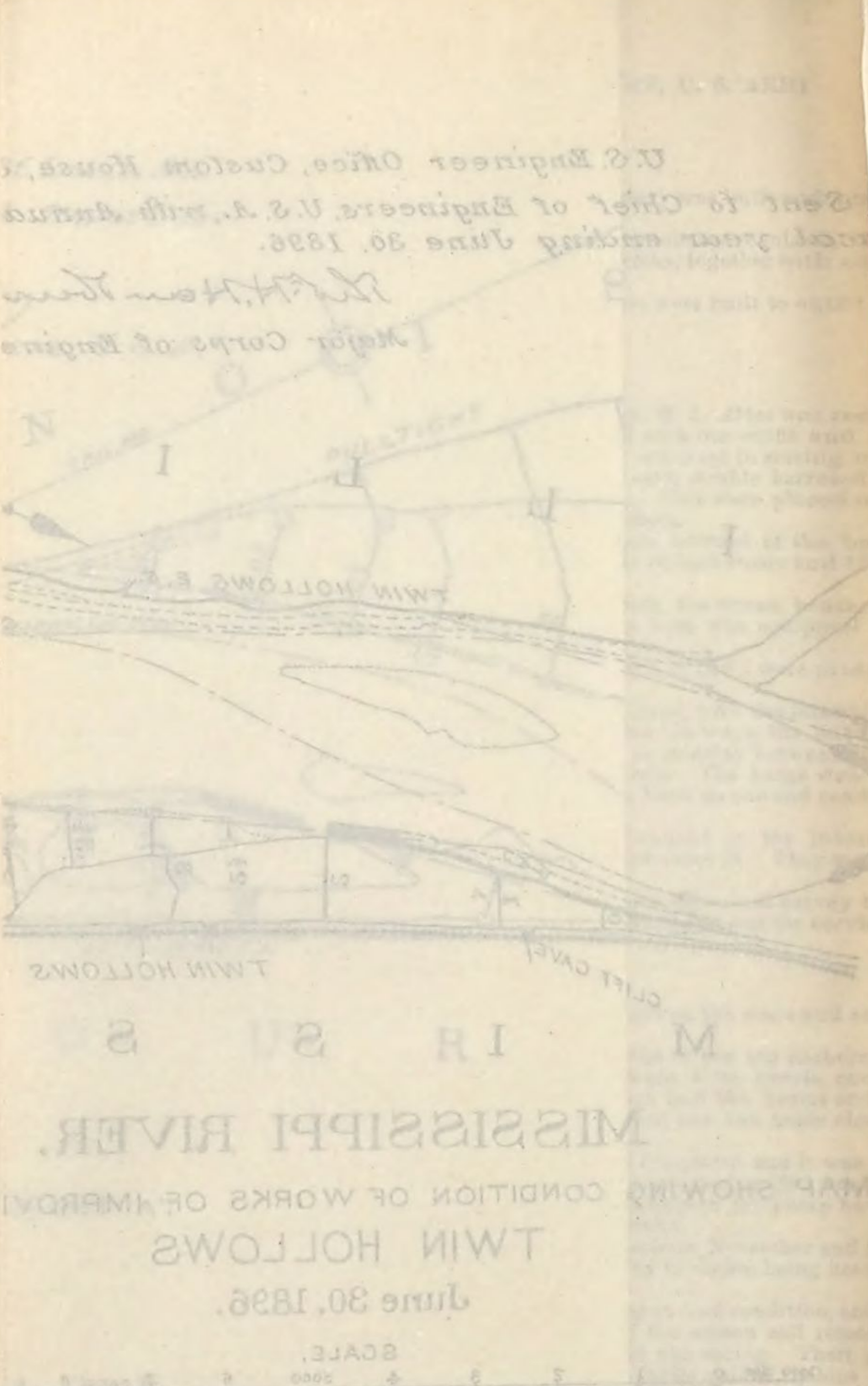


U. S Engineer Office, Custom House, St. Louis, Mo.
Sent to Chief of Engineers, U.S.A., with Annual Report for fiscal year ending June 30, 1896.

Thos. H. Handbury
Major Corps of Engineers, U. S. A.

ANDREW B GRAHAM PHOTO-LITHO WASHINGTON, D.C.

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MISSISSIPPI RIVER.

MAP SHOWING CONDITION OF WORKS OF IMPROVEMENT

TWIN HOLLOWS

June 30, 1896.

SCALE.

Plate 3.

MISSISSIPPI RIVER.

MAP SHOWING CONDITION OF WORKS OF IMPROVEMENT AT

SULPHUR SPRINGS, LUCAS' & CORNICE ISLAND,

June 30, 1896.

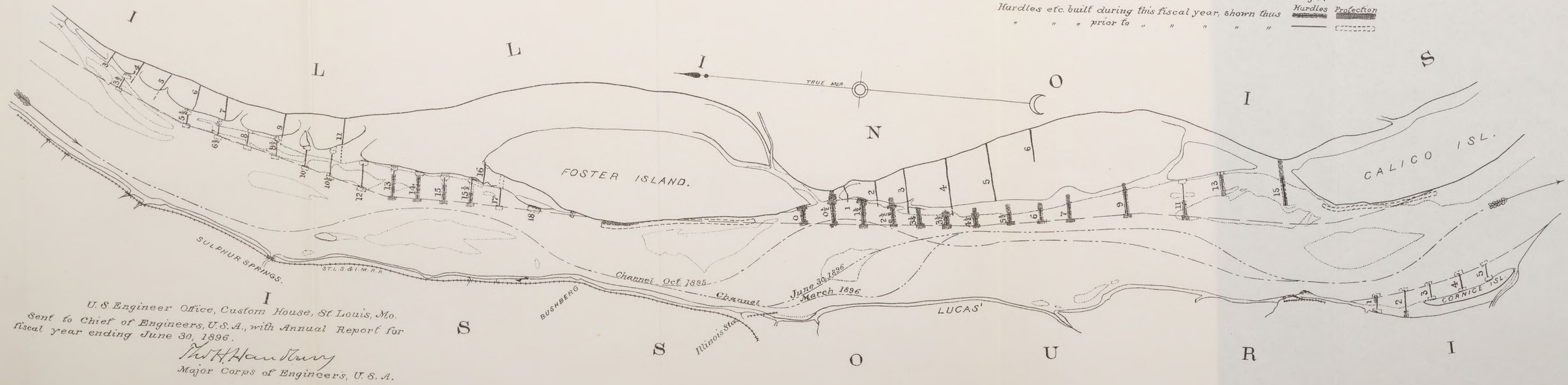
SCALE.

1000 500 0 1 2 3 4 5000 6 7 8 9 10000 Ft.

Bars are shown as they appeared during Aug. Sept. Oct. and Nov. 1895, at approximate standard low water stage.

Hurdles etc. built during this fiscal year, shown thus Hurdles Protection

" " " prior to " " " " "



U. S Engineer Office, Custom House, St. Louis, Mo.
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Thos. H. Handbury
Major Corps of Engineers, U. S. A.

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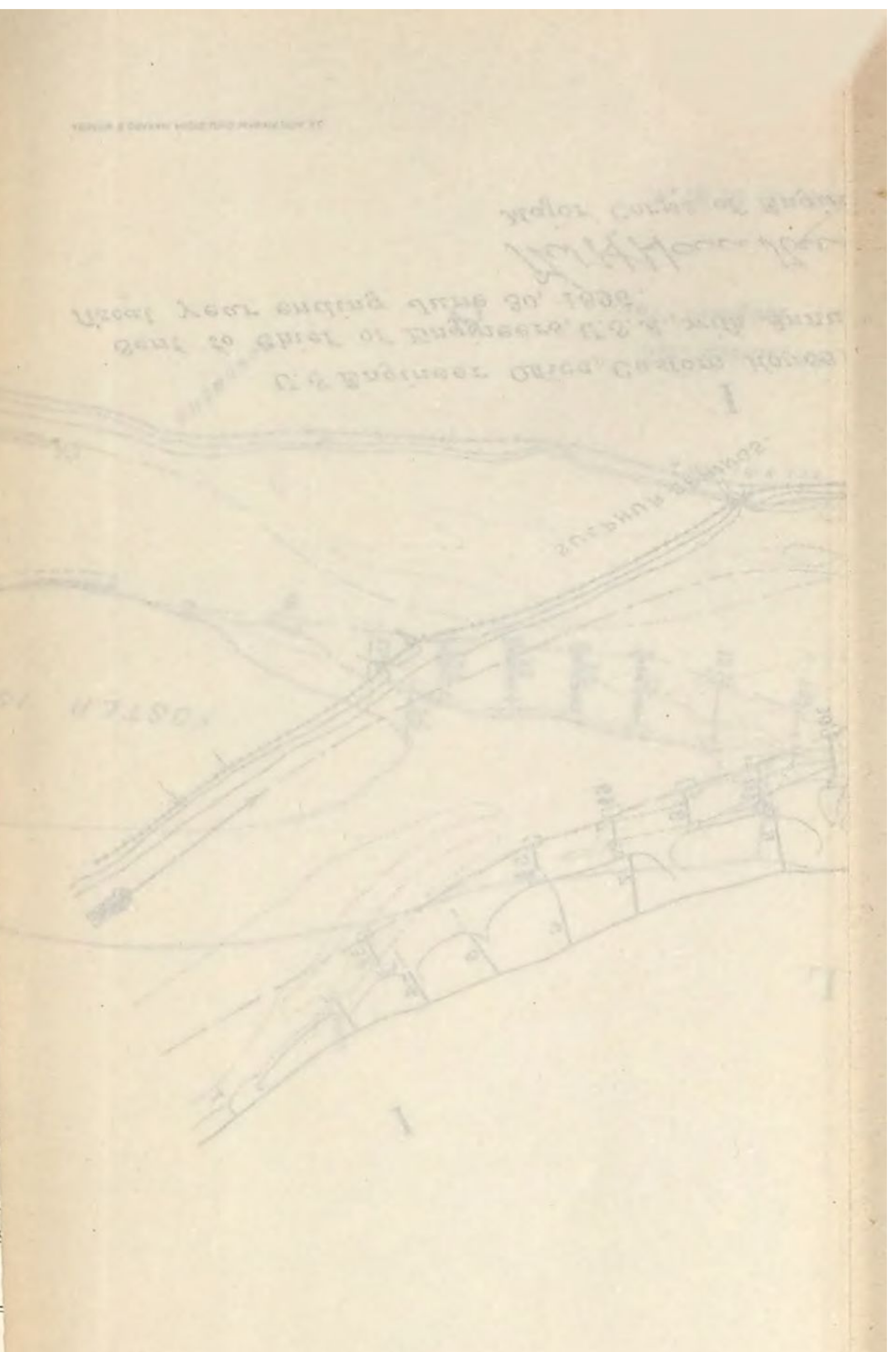


Plate 4.

MISSISSIPPI RIVER.

MAP SHOWING CONDITION OF WORKS OF IMPROVEMENT AT

RUSH TOWER & UPPER PART OF FORT CHARTRES,

June 30, 1896.

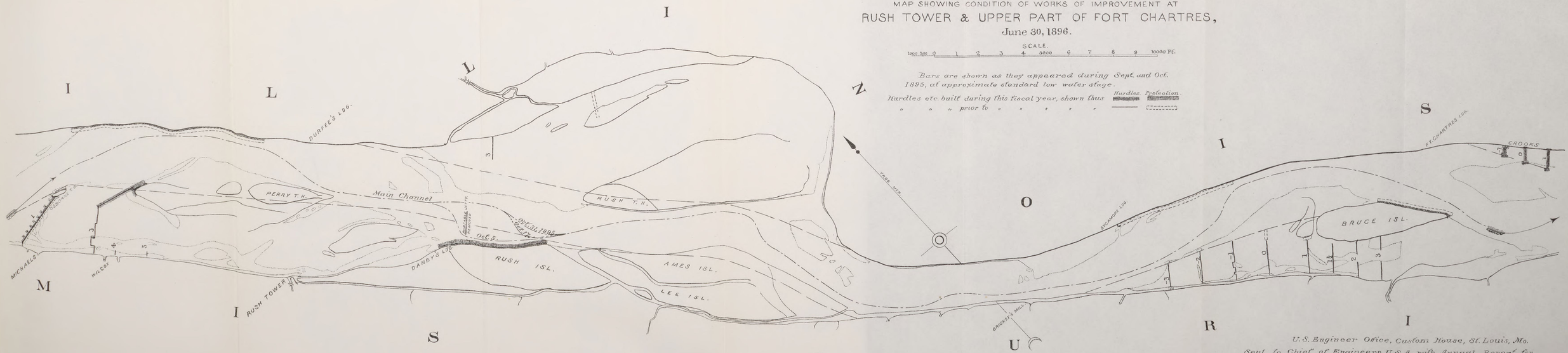
SCALE.

1000 500 0 1 2 3 4 5000 6 7 8 9 10000 Ft.

Bars are shown as they appeared during Sept. and Oct. 1895, at approximate standard low water stage.

Hurdles etc. built during this fiscal year, shown thus Hurdles. Protection.

" " " prior to " " " " "

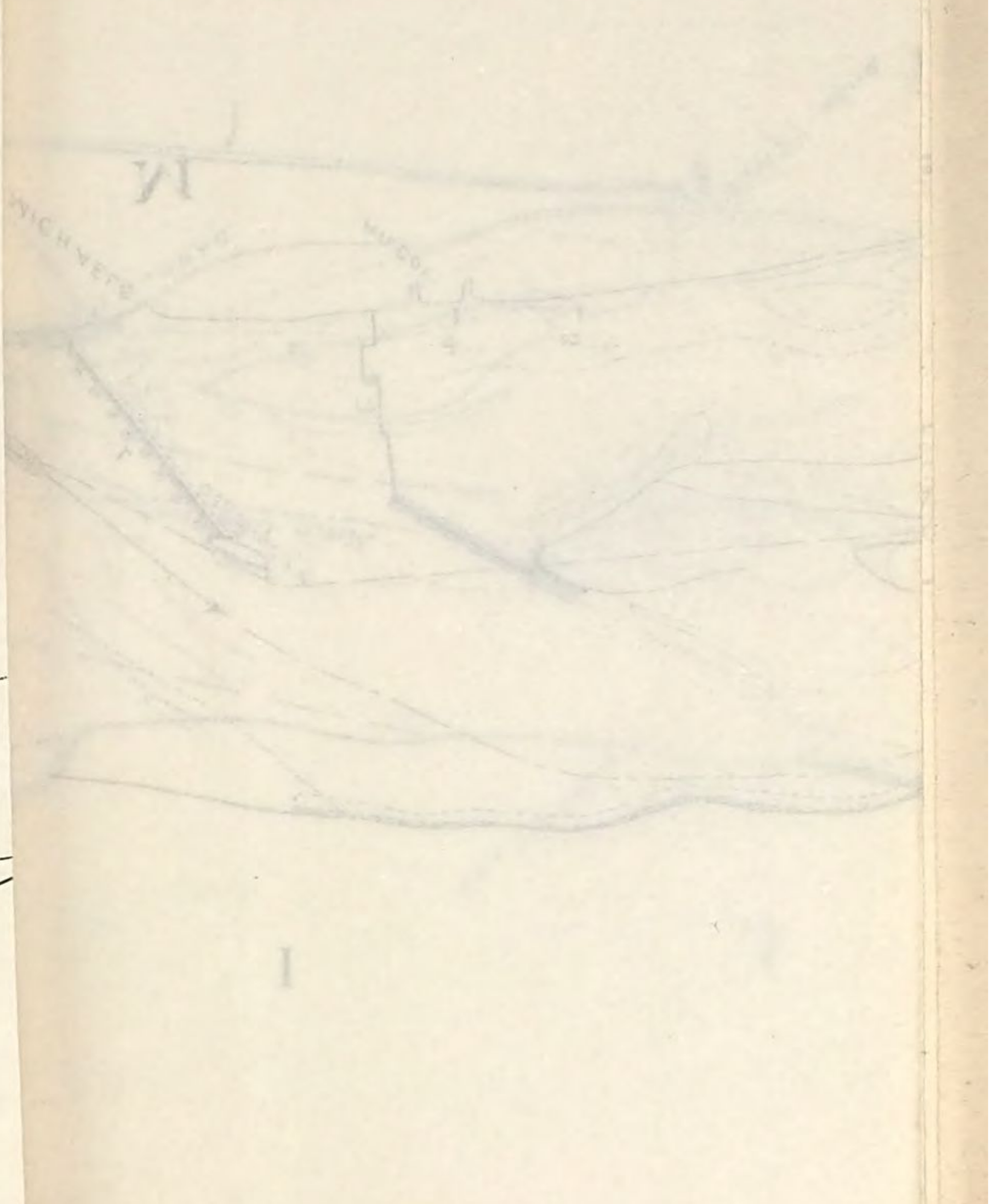


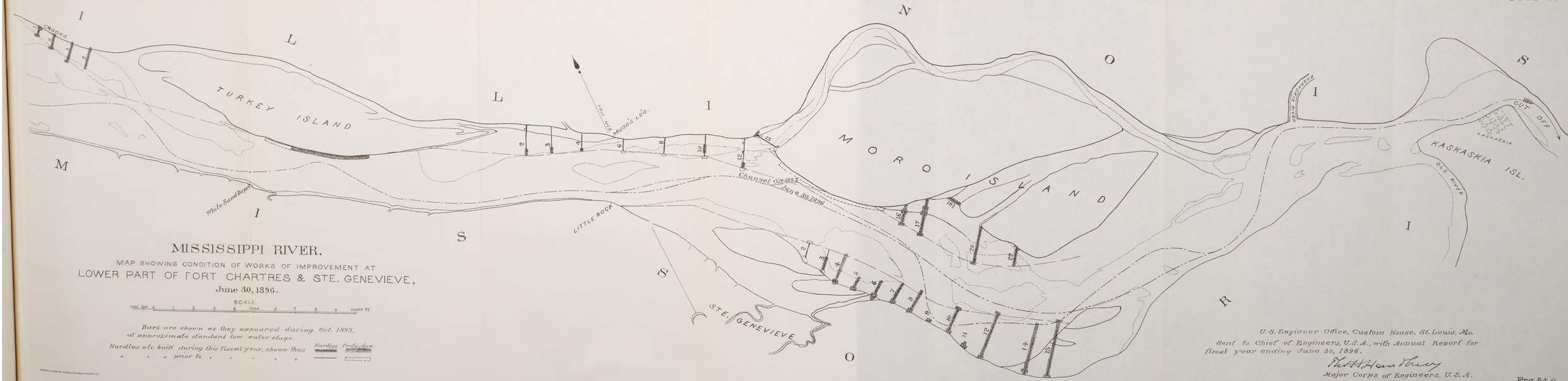
U.S. Engineer Office, Custom House, St. Louis, Mo.

Sent to Chief of Engineers, U.S.A., with Annual Report for fiscal year ending June 30, 1896.

H. M. Chittenden

Major Corps of Engineers, U.S.A.





MISSISSIPPI RIVER.

MAP SHOWING CONDITION OF WORKS OF IMPROVEMENT AT

LOWER PART OF FORT CHARTRES & STE. GENEVIEVE,

June 30, 1896.

SCALE.

1000 500 0 1 2 3 4 5000 6 7 8 9 10000 Ft

Bars are shown as they appeared during Oct. 1895, at approximate standard low water stage.

Hurdles etc built during this fiscal year, shown thus Hurdles. Protection.

" " " prior to " " " " "

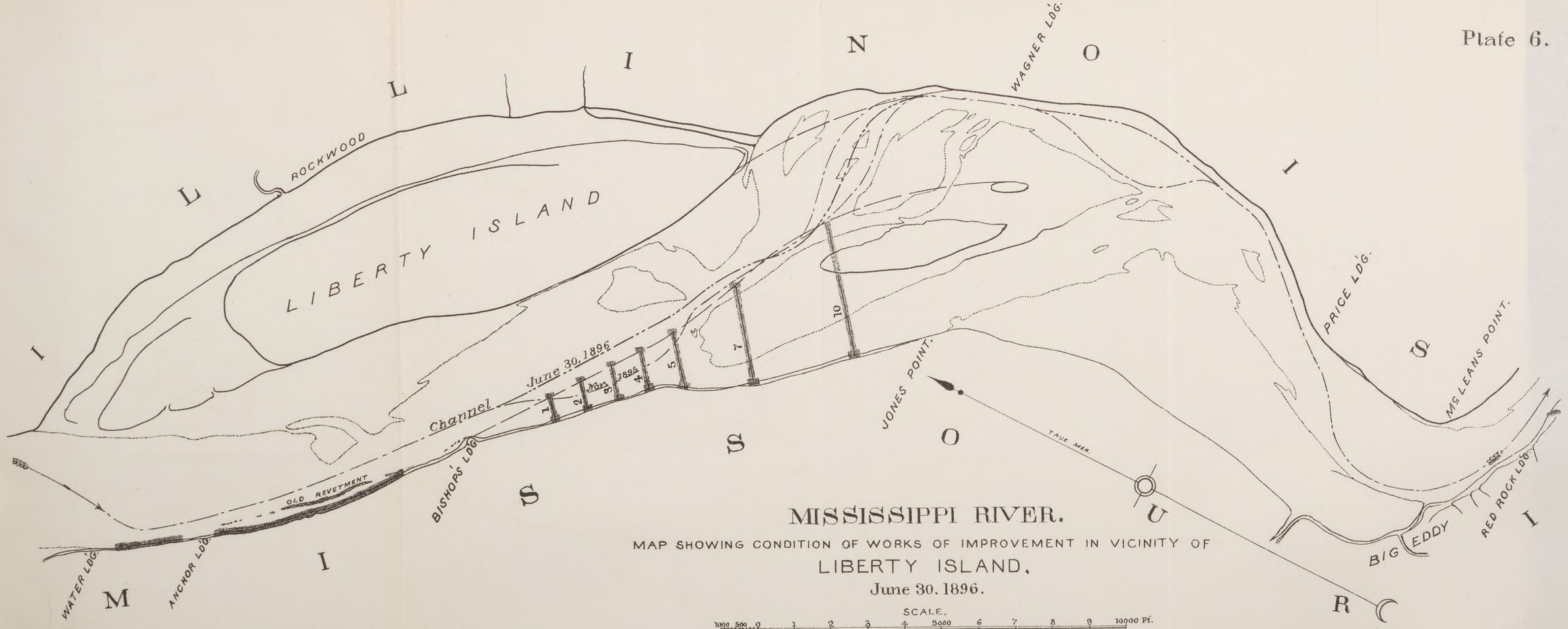
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Sent to Chief of Engineers, U.S.A., with Annual Report for fiscal year ending June 30, 1896.

Major Corps of Engineers, U. S. A.

Eng 54 2



Plate 6.



MAP SHOWING CONDITION OF WORKS OF IMPROVEMENT IN VICINITY OF

LIBERTY ISLAND,

June 30, 1896.

SCALE.

1000 500 0 1 2 3 4 5000 6 7 8 9 10000 Ft.

Bars are shown as they appeared during Oct. 1895, at approximate standard low water stage.

Hardles etc. built during this fiscal year, shown thus ——— Hardles. ——— Protection.

" " " prior to " " " " " ———

U.S. Engineer Office, Custom House, St. Louis, Mo.

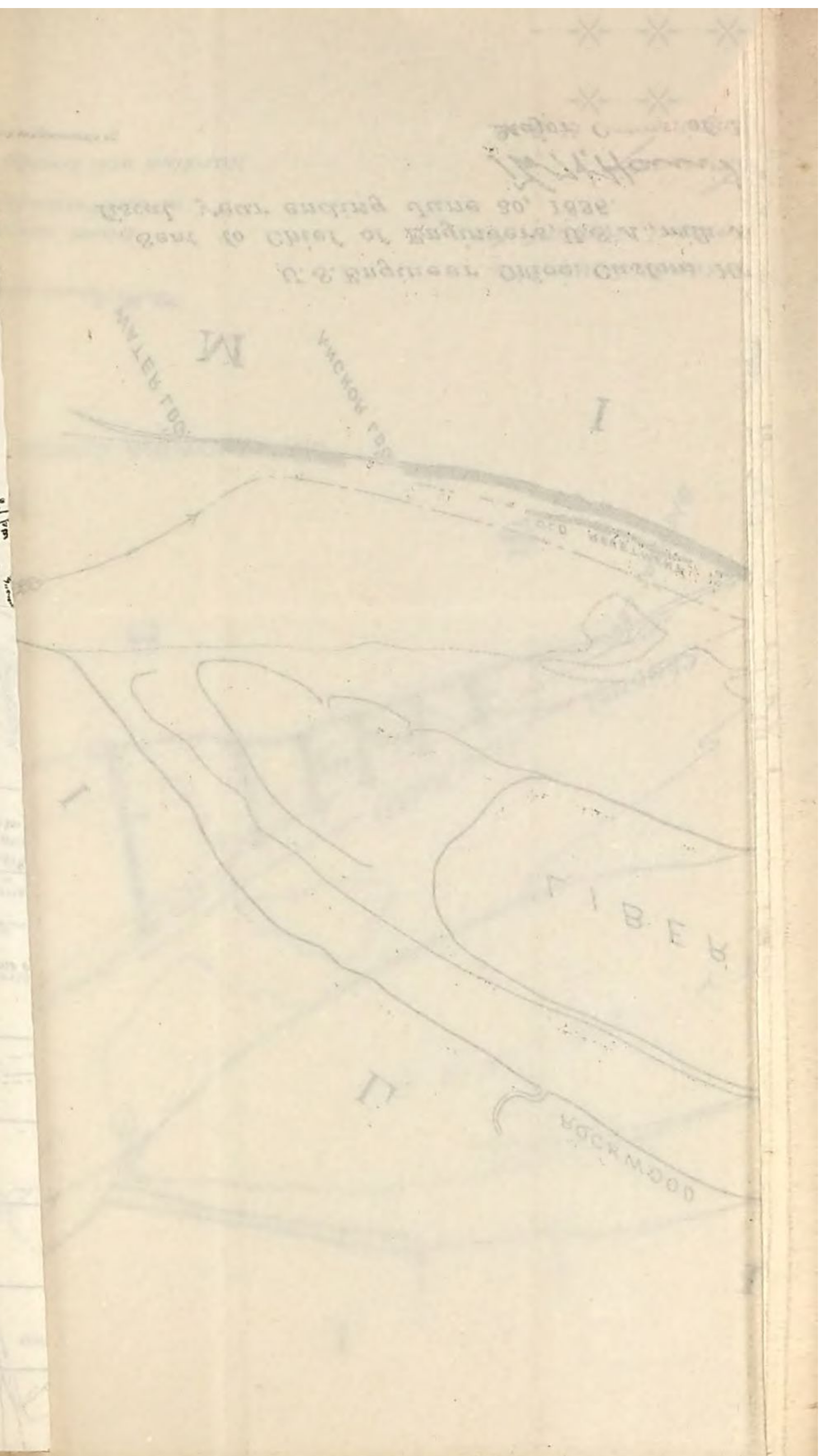
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W. H. Harrison

Major Corps of Engineers, U.S.A.

HERMAN & GRAHAM, PHOTO LITHO, WASHINGTON, D.C.

Eng 54 2


IV
KNOWN ROAD
I
B E A
II
KNOWN ROAD

MILES FROM ST LOUIS

St. Louis

Jefferson Barracks

Profiles of Slopes at time of annual hydrographic survey

Waters Point

Cornice Rock

St. Louis Directrix = 200

Profiles of Mean Depths from hydrographic survey

Scale of depth in feet

Profiles of Cross-Section Areas from hydrographic survey

Scale of area in sq. feet

Map showing location of Contraction Works

Scale in feet

Hurdles constructed before 1892, shown thus: ——
" " since 1892, " " ——
Numbers in channel denote miles from St. Louis.
Bars are shown as they appeared during Aug, Sept, Oct. & Nov, 1895 at approximate standard low water stage.

EAST ST. LOUIS · CAHOKIA · EADS BRIDGE GAUGE · ARSENAL · U.S. ENGR DEPOT · EAST CARONDELET · ST LOUIS · DES PERES R. · JEFFERSON BARRACKS GAUGE · HORSE TAIL · CARROLL · TWIN HOLLOWS · BULL LIGHT · BEARD · TRUE MER. · JIM SMITH · FOSTER · LUCAS · CAL CO. · CORNICE ROCK GAUGE · CRYSTAL CITY · TWIN HOLLOWS · MERAMEC R. · CHESLEY · KIMMSWICK · WATERS POINT GAUGE · SULPHUR SPRINGS · SULPHUR SPRINGS · BUSHBERG · LATHROP

MISSISSIPPI RIVER, ST. LOUIS TO CORNICE ROCK

Profiles of slopes, mean depths and cross-section areas at low stages, showing changes resulting from contraction works. Two Plates.

Compiled under the direction of

Major THOS. H. HANDBURY, Corps of Engineers, U.S. Army
by
John O. Holman, Assistant Engineer.

Profiles of 1892, shown thus ----------
" " 93, " "
" " 94, " "
" " 95, " "

U.S. Engineer Office, Custom House, St. Louis, Mo.

Sent to Chief of Engineers, U.S.A., with Annual Report for fiscal year ending June 30, 1896.

Thos. H. Handbury
Major Corps of Engineers, U.S.A.

ANDREW B. GRAHAM, PHOTO LITHO WASHINGTON, D.C.

Sent to Chief of Engineers, U.S.A.,
fiscal year ending June 30, 1898

Major C.

Steamer Gen. H. L. Abbot.—A new stock was made and placed on one of the wing rudders. Small repairs were also made as required upon the chocks, kevels, nosing, fenders, etc.; the roof was painted and hold cleaned and salted, being such repairs as could not be attended to by the boat's carpenter while it was in service.

Steamer Gen. T. L. Casey.—In addition to small repairs as noted for the *Gen. H. L. Abbot*, the packing rings of the main engines were refitted and an iron stock made of extra strong pipe 10 inches diameter and placed on the balance rudder.

Steamer Gen. Gillmore.—The *Gen. Gillmore* was also repaired as noted above, the escape pipe was renewed between the chimneys and the afterend of the boilers, and one engine bed was renewed.

Tenders.—Small repairs were made upon the wheels, fenders, and nosing of Tenders Nos. 1 to 7, as required, during the fall and spring. In addition to the above, Nos. 1, 2, 6, and 7, were pulled out at the close of the fall season and thoroughly calked, painted, and repaired before being launched in the spring.

No. 3 was docked in the spring and No. 4 in the fall and spring, the decayed top and side plank replaced with new, the rudders, wheel, nosing, etc., repaired, and the machinery overhauled.

No. 5 was repaired in June, and the Providence steam capstan, which had become unserviceable, was taken out and replaced with one of our own design, made like that on Tender No. 3.

A new rudder was made for No. 6 and the rudders of No. 7 repaired.

Barges.—The top sides of all the barges were calked twice during the year, and small repairs were also made upon the planking, bitts, kevels, etc., of Barges Nos. 103, 104, 105, 108, 111, 113, 122 and two new stems put into No. 123. A bulkhead was built in No. 30 while sunk at Chester, the barge raised, pulled out on the ways, and repaired.

Quarter barges.—Small repairs were made upon the top sides of Quarter Barges Nos. 4, 8, and 29 in the fall, and the decks of Nos. 26 and 27 were sheathed with 2-inch lumber.

Pile drivers.—No work was done during the year with the drivers of the old crab-frame pattern, Nos. 7, 8, 10, 11, 15, 19, and 20, and no repairs upon them were needed, but all the drivers with hoisting engines, 28 in number, were kept in serviceable condition by frequent repairs. These repairs include the strengthening of the iron leads and braces, relaying brick in furnaces, painting the cabin and leads, renewing the chocks, timberheads, kevels, etc., and general repairs to the pumps and engines.

Machine shop.—The roof of the machine shop was repaired and painted. The boiler failed to pass inspection in March and was replaced by the boiler from Pile Driver No. 10.

Small boats.—All the small boats at the supply depot on July 1, 1895, comprising 53 flats, 36 skiffs, and 5 yawls, were calked and sent out for service during the fall.

At the close of the season all the small boats except 7 skiffs and 3 flats were pulled out on the bank at the depot and stored for the winter. A small force of carpenters was engaged in repairing them until spring, when nearly all were calked and launched for use on the works. The number issued included 222 flats, 10 yawls, and 92 skiffs.

Portable quarters.—A shanty containing 6½ sections was repaired and set up on Barge No. 8. The quarters on Barges Nos. 26 and 27 were repaired and the roofs re-covered with canvas. A shanty of temporary quarters was set up at the Ste. Genevieve quarry.

Portable jetties.—The gates for jetties, 200 in number, were stiffened with 3 by 6 inch oak bolted to each angle iron during the winter, and were all painted during the spring.

Ways.—The ways were in almost constant use during the year, but no expense was incurred on their account, except in washing away the mud left by the rise of last December.

The plant docked during the year included 7 tenders, 13 pile drivers, and 6 barges.

Supply depot.—The roofs and sides of the warehouses, carpenter and blacksmith shops, and the iron fence were painted during the winter.

The mud was washed away from the river front in the spring by the wheels of the towboats, the water being deepened about 6 feet for a distance of 600 feet and a width of about 50 feet.

Tools and appliances and boarding outfit.—Tools and outfit of all kinds were repaired as required, a sufficient number being kept constantly on hand to supply the construction works and steamboats.

Materials and supplies.—All the materials and supplies used on the works of construction, except brush, stone, piles, ice, and coal, were received, stored, and handled at the supply depot during the year.

Very respectfully, your obedient servant,

C. D. LAMB,
Superintendent.

Maj. THOS. H. HANDBURY,
Corps of Engineers, U. S. A.

W 3.

IMPROVEMENT OF HARBOR AT ST. LOUIS, MISSOURI.

St. Louis Harbor has a length of about 18 miles, being divided into two nearly equal parts by the Eads Bridge. The upper portion of the harbor between this bridge and the northern limits of the city is about 10 miles in length. About 3 miles above the Eads Bridge is the Merchants Bridge. The lower portion of the harbor, included between the Eads Bridge and the River Des Peres, is about 8 miles long. A good depth of water and accessible landings exist in this lower part of the harbor, and a sufficient depth is found above the Merchants Bridge.

Between the Merchants and Eads bridges there had existed for a considerable number of years middle bars, and also shoals near the Illinois shore, which interfered with navigation, and which will be mentioned again further on.

Appropriations for improvement of St. Louis Harbor had been made as early as 1836, and a longitudinal stone dike was built at that time near the head of the present works by Capt. R. E. Lee, Corps of Engineers. Other work done in later years by the United States consisted in the building of stone and brush dikes generally normal to the direction of the current, in the closing of Cahokia Chute and the protection of the bank in Sawyer Bend.

The river and harbor act of Congress approved September 19, 1890, contained an appropriation of $182,000 for improving harbor at St. Louis, Mo., and the officer in charge, in submitting a project for its expenditure, recommended that the money be applied to the portion of the harbor between the Eads and Merchants bridges. The approved project consisted in contracting this portion of the river to a width of about 2,000 feet by means of a system of hurdles built along the Illinois shore for a distance of about 13,000 feet, with a view to removing the bars which then existed and which interfered with navigation at low stages of the river, and also to improve the ferry landings on the Illinois shore. The object of the hurdles was to cause deposits of sediment, and thus build up a new bank out to the line desired. They were 12 in number and spaced 1,000 feet apart. The hurdles, which were completed by July 1, 1892, were from 325 to 2,075 feet long. A full description of the manner of doing this work and the results obtained has been given in previous annual reports.

The navigable depth in the channel of the harbor between the line of hurdles and the opposite wharf line of St. Louis was, in December, 1893, 11 feet, the river standing at zero of the gauge, which is 4 feet below standard low water.

The amount expended to June 30, 1895, was $150,762.03. There were no expenditures during the last fiscal year.

The hurdles remain in fair condition, except that the extreme river ends are weakened each year by drift and gradual decay of the pile timber. Repairs will be needed shortly.

The balance, $31,084.63, remaining from the appropriation of 1890 has been reserved to repair damages that may occur to the hurdles and to extend them when necessary.

No further appropriation is asked for this work.

The commercial statistics pertaining to this portion of the river will be found in the report on the improvement of the Mississippi River

between the mouth of the Ohio River and the mouth of the Missouri River.

This work is in the collection district of New Orleans. The nearest port of entry is St. Louis, Mo., at which place the customs collected during the fiscal year ended June 30, 1896, amounted to $1,129,966.56.

The amount of internal revenue collected was $6,469,443.88.

Money statement.

July 1, 1895, balance unexpended	$31,237.97
July 1, 1896, balance unexpended	31,237.97
July 1, 1896, outstanding liabilities	153.34
July 1, 1896, balance available	31,084.63

W 4.

IMPROVEMENT OF KASKASKIA RIVER, ILLINOIS.

The amount, $10,500, originally estimated for completing this improvement having been appropriated and the work completed prior to July 1, 1895, no work was done during the past fiscal year, and no further appropriation is asked for.

By authority of the Chief of Engineers, dated December 12, 1895, this work was dropped from the duties in charge of this office. This report will therefore close the record.

Money statement.

July 1, 1895, balance unexpended	$39.20
December 16, 1895, deposited to the credit of the Treasurer of the United States	39.20

APPENDIX X.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN MOUTH OF MISSOURI RIVER AND MINNEAPOLIS, AND OF GALENA RIVER, ILLINOIS.

REPORT OF LIEUT. COL. W. R. KING, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Operating snag boats and dredge boats on Upper Mississippi River.
2. Mississippi River between Missouri River and Minneapolis.
3. Operating and care of Des Moines Rapids Canal and Dry Dock.
4. Operating and care of Galena River improvement, Illinois.
5. Construction of Lock and Dam No. 2, Mississippi River, between St. Paul and Minneapolis.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 10, 1896.

GENERAL: I have the honor to transmit herewith the annual reports upon the works in my charge during the fiscal year ending June 30, 1896.

Very respectfully, your obedient servant,

W. R. KING,
Lieut. Col., Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

X 1.

OPERATING SNAG BOATS AND DREDGE BOATS ON UPPER MISSISSIPPI RIVER.

The work performed under this appropriation is the removal of snags, wrecks, and other obstructions, the cutting and pulling back of overhanging trees, the clearing of shores, the searching for and marking of new channels, assisting stranded boats and barges, surveys and examinations in connection with new improvements and for facilitating navigation through bridges, inspection and repair of works, formation of temporary or permanent channels through obstructing bars, and in general in benefiting commerce by aiding existing navigation and assisting in the permanent improvement of the Upper Mississippi River.

The plant belonging to this work consists of the snag boats *General Barnard* and *J. G. Parke*, and to these are added, as occasion demands and circumstances permit, dredges, launches, barges, etc., belonging to the general appropriation. The operations of the snag boats and

dredges extend from Minneapolis to the mouth of the Missouri River, about 724 miles. At times when the snag boats are not required on work above mentioned they are used under general or special appropriations for work of permanent construction.

By the river and harbor act of August 11, 1888, provision was made for operating snag boats and dredge boats on the Upper Mississippi River under a permanent appropriation, the annual expenditure being limited by the act to $25,000. There has been expended under the permanent appropriation during the fiscal year ending June 30, 1896, the sum of $25,000.

The snag boat *General Barnard* was engaged in the work of removing snags, etc., from May 15 to November 5, 1895, and from March 26 to June 30, 1896. Dredge *Vulcan*, with towboat *Alert* as tender, was engaged during May and June, 1896, in widening the channel at the cut-off in Coon Slough. The snag boat *J. G. Parke* was employed on construction work between the Illinois and Missouri rivers under the general appropriation for improvement.

The details of work accomplished are given in the appended report of Assistant Engineer C. W. Durham.

Commercial statistics, a detailed statement, and a summary of expenditures for operating snag boats and dredge boats on Upper Mississippi River for the fiscal year ending June 30, 1896, are appended.

The total tonnage of the Mississippi River between the Falls of St. Anthony and mouth of Missouri River for the calendar year 1895 was, approximately, 3,000,000 tons. This includes logs and lumber as well as ordinary merchandise.

Abstract of appropriations.

By act approved March 2, 1867	$96,000
By allotment from appropriation of July 25, 1868	26,000
By allotment from appropriation of 1869	35,640
By act approved—	
July 11, 1870	36,000
March 3, 1871	42,000
June 10, 1872	42,000
March 3, 1873	25,000
June 23, 1874	25,000
March 3, 1875	25,000
August 14, 1876	30,000
June 18, 1878	41,500
March 3, 1879	20,000
June 14, 1880	8,000
March 3, 1881	25,000
By act passed August 2, 1882	25,000
By act approved August 5, 1886	22,500
By act of August 11, 1888, for fiscal year ending—	
June 30, 1889	25,000
June 30, 1890	25,000
June 30, 1891	25,000
June 30, 1892	25,000
June 30, 1893	25,000
June 30, 1894	25,000
June 30, 1895	25,000
June 30, 1896	25,000
Total	724,640

Money statement.

June 30, 1896, amount drawn from Treasury under permanent appropriation	$25,000.00
June 30, 1896, amount expended during fiscal year	25,000.00
July 1, 1896, amount available, under permanent appropriation of August 11, 1888, for fiscal year ending June 30, 1897	25,000.00

STATISTICS OF COMMERCE AND NAVIGATION.

Lumber.—The most important business carried on in connection with the navigation of the Upper Mississippi River and its principal tributaries is the lumber trade, which gave employment in 1895 to about 60 towboats, valued at $600,000. Along the river from Minneapolis to St. Louis 100 sawmills were operated by 75 wholesale lumber firms, having an invested capital of about $50,000,000. Their manufactures, in 1895, were: Lumber, 1,349,401,193 feet B. M.; shingles, 377,758,250; laths, 280,458,450. This shows an increase in manufacture, as compared with 1894, of: Lumber, 182,572,400 feet B. M.; shingles, 52,236,500; laths, 27,932,325.

In addition to the manufacturers there are a large number of retail or distributing firms.

Lumber manufacture, Upper Mississippi River Valley, 1895.

[Value about $34,000,000.]

Locality.	Lumber.	Shingles.
	Feet B. M.	*Number.*
Above Minneapolis	213,227,000	46,532,000
Minneapolis	479,102,000	99,338,000
St. Paul to St. Louis	713,027,000	214,188,000
St. Croix River	229,800,000	49,444,000
Black River	173,427,000	70,332,000
Chippewa River	302,381,000	138,204,000
Total	2,110,964,000	618,038,000

The larger part of the above was floated for greater or less distance on the Mississippi River, either as logs or lumber. The total product (excluding shingles and laths), if shipped by rail, would have loaded 175,914 cars of 12,000 feet each (about 20 tons), the quantity generally accepted by lumbermen as a carload. Supposing an average length of car of 35 feet, it would have loaded a train 1,166 miles in length, or 8,800 trains of 20 cars each.

Statement of distribution of lumber manufacture along the Upper Mississippi River from Minneapolis to St. Louis in 1895.

Locality.	Lumber.	Shingles.	Laths.
	Feet B. M.	*Number.*	*Number.*
Minneapolis	479,102,193	99,338,250	94,842,450
Hastings	8,211,000	.....	.....
Redwing	8,008,000	3,108,000	1,126,000
Alma	600,000	675,000	76,000
Winona	139,500,000	66,450,000	43,500,000
La Crosse	157,272,000	64,232,000	23,610,000
Prairie du Chien	13,500,000	12,000,000	5,000,000
Guttenberg	12,500,000	3,500,000	1,500,000
Cassville	1,000,000	900,000	200,000
Dubuque	44,300,000	6,000,000	6,000,000
Bellevue	6,140,000	.....	1,508,000
Lyons	18,000,000	4,858,000	2,850,000
Clinton	70,781,000	9,425,000	11,666,000
Fulton	14,000,000	4,500,000	2,500,000
Moline	21,500,000	4,350,000	4,900,000
Davenport	48,740,000	8,800,000	8,880,000
Rock Island	117,580,000	20,842,000	30,000,000
Muscatine	73,000,000	11,000,000	13,000,000
Burlington	27,167,000	9,250,000	4,500,000
Fort Madison	20,000,000	12,170,000	7,000,000
Keokuk	16,000,000	7,000,000	3,500,000
Canton	4,500,000	3,500,000	2,200,000
Quincy	23,000,000	13,860,000	6,100,000
Hannibal	25,000,000	12,000,000	6,000,000
Total	1,349,401,193	377,758,250	280,458,450

Lumber manufacture on the Mississippi River from St. Paul to St. Louis for ten years.

Year.	Lumber.	Shingles.	Laths.
	Feet B. M.	*Number.*	*Number.*
1895	870, 299, 000	278, 420, 000	185, 616, 000
1894	673, 572, 000	204, 198, 000	158, 586, 000
1893	811, 576, 588	285, 897, 000	190, 394, 800
1892	931, 806, 305	357, 014, 775	228, 042, 910
1891	814, 228, 707	332, 666, 750	207, 722, 350
1890	1, 231, 678, 960	508, 986, 705	.....
1889	1, 044, 555, 298	463, 132, 700	.....
1888	1, 048, 951. 386	423, 655, 050	.....
1887	988, 361, 094	363, 239, 750	.....
1886	934, 735, 854	274, 581, 750	267, 888, 340
Total	9, 349, 765, 192	3, 491, 792, 480	.....

Steamboats and freight.—The principal steamboat lines on the Upper Mississippi River are the Diamond Jo Line, the Eagle Packet Company, and the Joy Lumber Line. There are also many independent boats carrying freight and passengers. During the season of 1895 the amount of freight and number of passengers carried could not be accurately ascertained, but partial reports give 392,051 tons of freight and 239,205 passengers, not including those of ferry and excursion boats.

Taking into consideration the logs and lumber floated in the stream, the gross tonnage for 1895 was approximately 3,000,000 tons.

Statement of approximate tonnage of the Upper Mississippi River, Minneapolis to St. Louis, for ten years.

Year.	Tons.	Year.	Tons.
1886	3, 200, 000	1891*	3, 300, 000
1887	3, 500, 000	1892	3, 750, 000
1888	3, 750, 000	1893†	3, 200, 000
1889	3, 500, 000	1894*	2, 975, 000
1890	4, 200, 000	1895*	3, 000, 000

*Very low water. †Great business depression.

At St. Louis there were received in 1895 from the Upper Mississippi River by boats, barges, and rafts, 78,170 tons merchandise, 74,161,399 feet pine lumber, 24,766,937 shingles, and 18,033,750 laths. There were shipped to points on the Upper Mississippi River 30,780 tons merchandise.

Arrivals at and departures from St. Louis during 1895.

Steamboats and barges from Upper Mississippi River arrived at St. Louis..... 649
Steamboats and barges departed from St. Louis for Upper Mississippi River.... 639

The following table affords a comparative view of the relative amount of navigation at various localities on the Upper Mississippi River for the last three years:

List of steamboats, barges, and rafts passing through various bridges.

Locality of bridge.	Steamboats.			Barges.			Rafts.		
	1895.	1894.	1893.	1895.	1894.	1893.	1895.	1894.	1893.
Hastings	726	709	487	693	900	327	146	116	90
Winona	3, 745	3, 715	4, 428	1, 444	1, 422	1, 324	1, 325	1, 172	1, 655
La Crosse	2, 822	3, 017	3, 956	955	883	2, 091	1, 085	908	1, 407
Dubuque	1, 358	2, 132	2, 744	977	1, 128	1, 253	406	428	627
Sabula	1, 576	3, 783	2, 784	1, 078	1, 276	1, 233	(*)	(*)	(*)
Clinton	2, 308	2, 052	2, 491	467	667	659	501	†292	†411
Rock Island	2, 930	2, 110	2, 183	821	613	485	564	509	576
Keithsburg	996	1, 059	1, 108	440	(*)	(*)	†180	(*)	(*)
Burlington	1, 645	1, 462	1, 377	692	572	426	336	187	380
Fort Madison	1, 473	1, 272	1, 252	437	436	(*)	227	167	(*)
Keokuk	1, 317	1, 233	1, 678	519	901	1, 586	119	121	153
Quincy	1, 787	1, 757	1, 478	488	640	624	122	131	178
Hannibal	1, 381	1 792	1, 798	1, 447	1, 193	1, 117	372	177	309
Louisiana	1, 008	704	1, 313	745	488	797	34	46	53

*No record. †Partial record.

The following table shows the navigation during a period of eighteen years through Winona Bridge, at which point the traffic is the largest:

Statement of steamers, barges, and rafts passing Winona Bridge during eighteen years.

Year.	Steamboats.	Barges.	Rafts.	Year.	Steamboats.	Barges.	Rafts.
1878	2,948	1,115	863	1887	4,309	1,600	1,100
1879	3,760	1,362	1,889	1888	4,740	684	1,894
1880	4,593	883	1,392	1889	4,419	1,140	1,387
1881	4,739	575	1,717	1890	5,417	1,045	2,123
1882	5,627	942	1,939	1891	3,687	1,108	1,495
1883	4,893	828	1,352	1892	5,268	957	1,759
1884	4,992	905	2,007	1893	4,428	1,324	1,655
1885	5,126	848	1,973	1894	3,715	1,422	1,172
1886	4,570	974	1,860	1895	3,745	1,444	1,325

Internal revenue for the year ending December 31, 1895, collected in districts bordering on the Upper Mississippi River.

Locality.	Office.	Amount.
Minnesota	St. Paul	$2,160,810.08
Second Wisconsin	Madison	477,462.56
Third Iowa	Dubuque	157,681.21
Fourth Iowa	Burlington	289,756.79
Fifth Illinois	Peoria	13,122,707.63
Eighth Illinois	Springfield	10,169,394.10
Thirteenth Illinois	Cairo	595,299.49
First Missouri	St. Louis	6,705,575.72
Total		33,678,687.58

Customs revenue and tonnage for the year ending December 31, 1895.

Port.	Collections.	Tonnage enrolled.	Vessels.
St. Paul, Minn	$320,760.20	2,204.53	27
La Crosse, Wis	104.65	5,117.31	63
Dubuque, Iowa	9,906.81	6,376.55	24
Rock Island, Ill	.....	6,637.28	67
Burlington, Iowa	20.93	799.84	10
St. Louis, Mo.*	1,209,670.27	120,578.28	204
Total	1,540,462.86	141,713.79	395

*Only a part of the St. Louis statement applicable to the Upper Mississippi.

Detailed statement of expenditures for operating snag boats and dredge boats on Upper Mississippi River for the fiscal year ending June 30, 1896.

Number of voucher.	To whom paid.	Total.	Office expenses, superintendence, and contingencies.	Labor.	Subsistence.	Fuel.	Expense.	Repairs.
	July, 1895.							
1	C. W. Durham	$4.00	$4.00	.....	.....	.....	.....	.....
2	Hired men	1,429.33	.....	$1,429.33	.....	.....	.....	.....
3	.....do	24.33	.....	24.33	.....	.....	.....	.....
	Total	1,457.66	4.00	1,453.66	.....	.....	.....	.....
	August, 1895.							
1	C. W. Durham	4.25	4.25	.....	.....	.....	.....	.....
2	C. W. Suman	33.33	.....	.....	.....	.....	.....	$33.33

Detailed statement of expenditures for operating snag boats and dredge boats on Upper Mississippi River for the fiscal year ending June 30, 1896—Continued.

Number of voucher.	To whom paid.	Total.	Office expenses, superintendence, and contingencies.	Labor.	Subsistence.	Fuel.	Expense.	Repairs.
	August, 1895—Continued.							
3	A. D. Thomas	$11.80	.....	.....	.....	.....	.....	$11.80
4	Trenton Iron Co	42.56	.....	.....	.....	.....	.....	42.56
5	Wm. A. Sutor	237.60	.....	.....	.....	$237.60	.....	.....
6	Ralph Levi	209.00	.....	.....	.....	209.00	.....	.....
7	Gentzkow Bros	132.00	.....	.....	.....	132.00	.....	.....
8	W. E. Nottingham	44.00	.....	.....	.....	44.00	.....	.....
9	John B. Flick	12.00	.....	.....	.....	12.00	.....	.....
10	L. Biethan	34.00	.....	.....	.....	34.00	.....	.....
11	Furlong Grocery Co	126.71	.....	.....	$125.81	.....	$0.90	.....
12	J. J. Hogan	59.15	.....	.....	48.59	.....	10.56	.....
13	E. Fritz	23.49	.....	.....	23.49	.....	.....	.....
14	Bergoust Grocery Co	32.37	.....	.....	32.37	.....	.....	.....
15	People's Ice Co	11.00	.....	.....	11.00	.....	.....	.....
16	J. Kieffer	90.61	.....	.....	90 61	.....	.....	.....
17	John H. Rippe	16.29	.....	.....	16.29	.....	.....	.....
18	August Peters	19.49	.....	.....	19.49	.....	.....	.....
19	Chas. J. Long	9.54	.....	.....	9.54	.....	.....	.....
20	The Pilot Steamboat Co	64.00	.....	.....	.....	64.00	.....	.....
21	Empire Coal Co	48.00	.....	.....	.....	48.00	.....	.....
22	Thos. E. Schindler & Co	27.09	.....	.....	27.09	.....	.....	.....
23	Standard Oil Co	33.73	.....	.....	.....	.....	33.73	.....
24	T. Nodler	13.48	.....	.....	13.38	.....	.10	.....
25	Frank J. Weess	34.60	.....	.....	34.60	.....	.....	.....
26	Conrad Bros	8.21	.....	.....	8.21	.....	.....	.....
27	L. Biethan	61.30	.....	.....	1.80	59.50	.....	.....
28	George Peter	3.92	.....	.....	3.92	.....	.....	.....
29	John Whitfield	6.00	.....	.....	6.00	.....	.....	.....
30	Andrew F. Koettker	14.83	.....	.....	14.83	.....	.....	.....
31	Alois Boschert & Co	43.70	.....	.....	43.70	.....	.....	.....
32	W. A. Bonsack	26.35	.....	.....	.....	.....	.....	26.35
33	John M. Keiflein	126.00	.....	.....	.....	126.00	.....	.....
34	Frank Brink	10.00	.....	.....	.....	10.00	.....	.....
35	Quincy Coal Co	25.60	.....	.....	.....	25.60	.....	.....
36	W. R. King	24.00	.....	.....	.....	24.00	.....	.....
37	Hired men	1,455.00	.....	$1,455.00	.....	.....	.....	.....
	Total	3,175.00	$4.25	1,455.00	530.72	1,025.70	45.29	114.04
	September, 1895.							
1	C. W. Durham	4.25	4.25	.....	.....	.....	.....	.....
2	.....do	4.50	4.50	.....	.....	.....	.....	.....
3	Wm. A. Sutor	44.00	.....	.....	.....	44.00	.....	.....
4	Haug & Co	21.00	.....	.....	.....	21.00	.....	.....
5	Diamond Jo Line steamers	36.00	.....	.....	.....	36.00	.....	.....
6	Wilke Bros	57.20	.....	.....	1.20	56.00	.....	.....
7	Anchor Line store	85.16	.....	.....	56.98	.....	28.18	.....
8	.....do	135.01	.....	.....	128.71	.....	6.30	.....
9	J. H. Scrogum	12.38	.....	.....	12.38	.....	.....	.....
10	Chas. J. Long	10.86	.....	.....	10.86	.....	.....	.....
11	Thos. E. Schindler & Co	14.94	.....	.....	14.94	.....	.....	.....
12	Empire Coal Co	24.00	.....	.....	.....	24.00	.....	.....
13	C. W. Suman	2.75	.....	.....	.....	.....	.....	2.75
14	J. J. Hogan	122.66	.....	.....	111.66	.....	11.00	.....
15	E. Fritz	17.70	.....	.....	17.70	.....	.....	.....
16	J. H. Scrogum	5.40	.....	.....	5.40	.....	.....	.....
17	Furlong Grocery Co	26.10	.....	.....	26.10	.....	.....	.....
18	J. Kieffer	41.85	.....	.....	41.85	.....	.....	.....
19	Gentzkow Bros	86.75	.....	.....	9.75	77.00	.....	.....
20	S. W. Vanderwarker	32.80	.....	.....	.....	32.80	.....	.....
21	James Latschaw	9.00	.....	.....	.....	9.00	.....	.....
22	Diamond Jo Line steamers	31.50	.....	.....	.....	31.50	.....	.....
23	T.C. Bright	27.50	.....	.....	.....	27 50	.....	.....
24	C. W. Durham	7.25	7.25	.....	.....	.....	.....	.....
25	W. A. Bonsack	19.85	.....	.....	.....	.....	.....	19.85
26	J. J. Hogan	18.39	.....	.....	10.50	.....	7.89	.....
27	A. Boschert & Co	17.50	.....	.....	17.50	.....	.....	.....
28	Andrew F. Koettker	10.65	.....	.....	10.65	.....	.....	.....
29	Wm. A. Sutor	66.00	.....	.....	.....	66.00	.....	.....
30	Wilke Bros	16.00	.....	.....	.....	16.00	.....	.....
31	R. T. Largent	5.00	.....	.....	.....	5.00	.....	.....

Detailed statement of expenditures for operating snag boats and dredge boats on Upper Mississippi River for the fiscal year ending June 30, 1896—Continued.

Number of voucher.	To whom paid.	Total.	Office expenses, superintendence, and contingencies.	Labor.	Subsistence.	Fuel.	Expense.	Repairs.
	September, 1895—Continued.							
32	Crown Coal and Tow Co	$63.00	.....	.....	.....	$63.00	.....	.....
33	Eagle Boat Store Co	45.50	.....	.....	$5.25	.....	$40.25	.....
34	.....do	256.17	.....	.....	.....	.....	242.67	$13.50
35	James Phillips	20.00	.....	.....	.....	20.00	.....	.....
36	L. Biethan	40.46	.....	.....	.....	40.46	.....	.....
37	David Don	2.85	.....	.....	.....	.....	2.85	.....
38	Frank J. Weess	14.85	.....	.....	14.85	.....	.....	.....
39	R. S. Owen	60.00	.....	.....	.....	60.00	.....	.....
40	W. R. King	44.80	.....	.....	.....	44.80	.....	.....
41	Hired men	1,401.00	.....	$1,401.00	.....	.....	.....	.....
42	.....do	80.67	.....	80.67	.....	.....	.....	.....
43	.....do	76.10	.....	.....	.....	.....	.....	76.10
	Total	3,119.35	$16.00	1,481.67	496.28	674.06	339.14	112.20
	October, 1895.							
1	Empire Coal Co	48.00	.....	.....	.....	48.00	.....	.....
2	Chas. J. Long	23.13	.....	.....	17.23	.....	5.90	.....
3	Thos. E. Schindler & Co	52.33	.....	.....	52.33	.....	.....	.....
4	Klindt, Geiger & Co	18.65	.....	.....	18.65	.....	.....	.....
5	Furlong Grocery Co	37.21	.....	.....	35.51	.....	1.70	.....
6	Bergoust Grocery Co	8.74	.....	.....	8.74	.....	.....	.....
7	J. H. Scrogum	14.34	.....	.....	14.34	.....	.....	.....
8	J. Kieffer	39.23	.....	.....	39.23	.....	.....	.....
9	Wilke Bros	48.00	.....	.....	.....	48.00	.....	.....
10	Haug & Co	52.50	.....	.....	.....	52.50	.....	.....
11	W. H. Pape	10.00	.....	.....	.....	10.00	.....	.....
12	Gentzkow Bros	99.00	.....	.....	.....	99.00	.....	.....
13	S. W. Vanderwarker	32.80	.....	.....	.....	32.80	.....	.....
14	Wm. A. Sutor	22.00	.....	.....	.....	22.00	.....	.....
15	.....do	44.00	.....	.....	.....	44.00	.....	.....
16	F. J. Fugina	55.00	.....	.....	.....	55.00	.....	.....
17	Noble, Wickett & Co	5.72	.....	.....	5.72	.....	.....	.....
18	W. R. King	52.00	.....	.....	.....	52.00	.....	.....
19	Empire Coal Co	114.40	.....	.....	.....	114.40	.....	.....
20	C. W. Suman	18.00	.....	.....	.....	.....	.....	18.00
21	Chas. J. Long	69.74	.....	.....	69.74	.....	.....	.....
22	Thos. E. Schindler & Co	35.87	.....	.....	35.87	.....	.....	.....
23	Sam'l Scott & Sons	6.07	.....	.....	6.07	.....	.....	.....
24	C. W. Durham	5.50	5.50	.....	.....	.....	.....	.....
25	E. F. W. Meier	28.05	.....	.....	.....	.....	28.05	.....
26	L. Biethan	40.28	.....	.....	.....	40.28	.....	.....
27	Quincy Coal Co	14.08	.....	.....	.....	14.08	.....	.....
28	Crown Coal and Tow Co	115.50	.....	.....	.....	115.50	.....	.....
29	Eagle Boat Store Co	106.20	.....	.....	43.84	.....	62.36	.....
30	Andrew F. Koettker	19.26	.....	.....	19.26	.....	.....	.....
31	Standard Oil Co	6.00	.....	.....	.....	.....	6.00	.....
32	Hired men	1,485.00	.....	1,485.00	.....	.....	.....	.....
33	C. W. Durham	250.00	250.00	.....	.....	.....	.....	.....
	Total	2,976.60	255.50	1,485.00	366.53	747.56	104.01	18.00
	November, 1895.							
1	T. C. Bright	55.00	.....	.....	.....	55.00	.....	.....
2	Hugo Becker	48.00	.....	.....	.....	48.00	.....	.....
3	Gentzkow Bros	95.70	.....	.....	.....	95.70	.....	.....
4	C. E. Macy	121.00	.....	.....	.....	121.00	.....	.....
5	J. H. Scrogum	7.60	.....	.....	7.60	.....	.....	.....
6	Hired men	121.17	.....	121.17	.....	.....	.....	.....
7	Frank J. Weess	5.80	.....	.....	5.80	.....	.....	.....
8	St. Louis, Keokuk and North Western R. R. Co	45.00	.....	45.00	.....	.....	.....	.....
9	Empire Coal Co	81.60	.....	.....	.....	81.60	.....	.....
10	N. H. Phillips	15.75	.....	.....	.....	15.75	.....	.....
11	Mississippi Coal and Ice Co	34.44	.....	.....	.....	34.44	.....	.....
12	Thos. E. Schindler & Co	41.71	.....	.....	41.71	.....	.....	.....
13	Chas. J. Long	2.10	.....	.....	2.10	.....	.....	.....
14	C. W. Durham	12.84	12.84	.....	.....	.....	.....	.....

Detailed statement of expenditures for operating snag boats and dredge boats on Upper Mississippi River for the fiscal year ending June 30, 1896—Continued.

Number of voucher.	To whom paid.	Total.	Office expenses, superintendence, and contingencies.	Labor.	Subsistence.	Fuel.	Expense.	Repairs.
	November, 1895—Continued.							
15	Hired men	$353.14	.....	$353.14	.....	.....	.....	.....
16	.....do	362.50	$75.00	222.50	.....	.....	.....	$65.00
	Total	1,403.35	87.84	741.81	$57.21	$451.49	.....	65.00
	December, 1895.							
1	Hired men	305.00	75.00	230.00	.....	.....	.....	.....
	January, 1896.							
1	Hired men	256.00	.....	230.00	.....	.....	.....	26.00
	February, 1896.							
1	C. W. Durham	7.75	7.75	.....	.....	.....	.....	.....
2	S. C. and S. Carter	41.08	.....	.....	.....	.....	.....	41.08
3	Hired men	303.50	.....	230.00	.....	.....	.....	73.50
4	.....do	11.06	.....	.....	.....	.....	.....	11.06
5	McElroy Iron Works	8.25	.....	.....	.....	.....	.....	8.25
6	Wilkinson & Co	2.42	.....	.....	.....	.....	.....	2.42
	Total	374.06	7.75	230.00	.....	.....	.....	136.31
	March, 1896.							
1	C. W. Durham	10.30	10.30	.....	.....	.....	.....	.....
2	Metropolis Saw Mill Co	39.45	.....	.....	.....	.....	.....	39.45
3	Hired men	178.00	.....	52.50	.....	.....	.....	125.50
4	Price Bros	226.01	.....	.....	.....	.....	.....	226.01
5	T. Nodler	22.30	.....	.....	21.70	.....	$0.60	.....
6	Frank J. Weess	25.30	.....	.....	25.30	.....	.....	.....
7	Hired men	692.50	.....	692.50	.....	.....	.....	.....
8	.....do	302.65	.....	.....	.....	.....	.....	302.65
9	A. D. Thomas	51.14	.....	.....	.....	.....	.....	51.14
	Total	1,547.65	10.30	745.00	47.00	.....	.60	744.75
	April, 1896.							
1	C. W. Durham	5.25	5.25	.....	.....	.....	.....	.....
2	A. Weber Co	3.61	.....	.....	.....	.....	.....	3.61
3	.....do	7.74	.....	.....	.....	.....	.....	7.74
4	Anchor Line Store	463.74	.....	.....	351.42	.....	112.32	.....
5	George Boschert	39.52	.....	.....	39.52	.....	.....	.....
6	Jacob Stocke	15.90	.....	.....	15.90	.....	.....	.....
7	Eagle Boat Store Co	94.15	.....	.....	.....	.....	94.15	.....
8	Crown Coal and Tow Co	136.50	.....	.....	.....	136.50	.....	.....
9	W. A. Bonsack	14.24	.....	.....	.....	.....	.....	14.24
10	C. W. Durham	5.00	5.00	.....	.....	.....	.....	.....
11	McCabe Bros	8.15	.....	.....	.....	.....	8.15	.....
12	T. H. Thomas	9.85	.....	.....	.....	.....	.....	9.85
13	Thos. E. Schindler & Co	34.81	.....	.....	34.81	.....	.....	.....
14	Hess Bros	9.90	.....	.....	9.90	.....	.....	.....
15	T. Nodler	15.65	.....	.....	15.65	.....	.....	.....
16	Frank J. Weess	28.56	.....	.....	28.56	.....	.....	.....
17	Jacob Richtman	29.00	.....	.....	.....	29.00	.....	.....
18	W. R. King	16.00	.....	.....	.....	16.00	.....	.....
19	Anton Brink	13.75	.....	.....	.....	13.75	.....	.....
20	Variety Wood Works	5.90	.....	.....	.....	.....	.....	5.90
21	Klindt, Geiger & Co	16.70	.....	.....	16.70	.....	.....	.....
22	Harry Clark	36.00	.....	.....	.....	36.00	.....	.....
23	J. H. Scrogum	4.45	.....	.....	4.45	.....	.....	.....
24	Wm. A. Sutor	26.84	.....	.....	.....	26.84	.....	.....
25	C. E. Macy	61.16	.....	.....	.....	61.16	.....	.....
26	Hired men	1,310.00	.....	1,310.00	.....	.....	.....	.....
27	.....do	500.00	500.00	.....	.....	.....	.....	.....
28	C. W. Durham	3.00	3.00	.....	.....	.....	.....	.....
	Total	2,915.37	513.25	1,310.00	516.91	319.25	214.62	41.34

Detailed statement of expenditures for operating snag boats and dredge boats on Upper Mississippi River for the fiscal year ending June 30, 1896—Continued.

Number of voucher.	To whom paid.	Total.	Office expenses, superintendence, and contingencies.	Labor.	Subsistence.	Fuel.	Expense.	Repairs.
	May, 1896.							
1	C. W. Durham	$4.25	$4.25					
2	The Pilot Steamboat Co	105.40				$105.40		
3	Gentzkow Bros	49.00			$5.00	44.00		
4	F. H. Ketcham	79.06				79.06		
5	McElroy Iron Works Co	1.31						$1.31
6	Gentzkow Bros	69.75			3.75	66.00		
7	Wm. A. Sutor	77.00				77.00		
8	Furlong Grocery Co	7.10			7.10			
9	J. Kieffer	26.82			26.82			
10	Hess Bros	12.25			12.25			
11	Thos. E. Schindler & Co	47.29			47.29			
12	J. H. Scrogum	3.80			3.80			
13	The Pilot Steamboat Co	108.50			108.50			
14	A. J. Martin	12.00			12.00			
15	Wm. Ewers & Son	11.56			11.56			
16	R. H. Stillwell	12.00			12.00			
17	Hired men	1,310.00	75.00	$1,235.00				
18	.....do	890.91		890.91				
19	F. H. Ketcham	23.45				23.45		
	Total	2,851.45	79.25	2,125.91	250.07	394.91		1.31
	June, 1896.							
1	Eagle Boat Store Co	291.30			197.61		$63.12	30.57
2	Eagle Boat Store Co	128.96					128.96	
3	Crown Coal and Tow Co	156.00				156.00		
4	W. A. Bonsack	5.44						5.44
5	John Sorrell	52.67			52.67			
6	Jacob Stocke	21.15			21.15			
7	August Peters	21.69			21.69			
8	M. S. Roster	10.54			10.54			
9	C. W. Durham	7.25	7.25					
10	Albert Kirchner	106.42			103.07		3.35	
11	Chas. Kirchner & Bro	40.48			40.48			
12	Charles Doering	14.67					14.67	
13	A. Weber Co	2.24						2.24
14	R. H. Stillwell	8.00			8.00			
15	J. J. Hogan	106.07			87.17		18.90	
16	W. A. Roosevelt Co	43.94					43.94	
17	James McCord	73.49					73.49	
18	Fred Kroner Hardware Co	15.49					11.74	3.75
19	D. Santo	11.75			11.75			
20	Hess Bros	17.49			14.43		3.06	
21	Thos. E. Schindler & Co	25.95			25.95			
22	The Pilot Steamboat Co	46.50				46.50		
23	Wm. A. Suter	77.00				77.00		
24	W. F. Grady	8.78	8.78					
25	C. W. Durham	4.75	4.75					
26	Harry Clark	45.00				45.00		
27	Uttley & White	18.69			18.69			
28	J. Kieffer	14.94			14.94			
29	Hired men	1,076.75		1,076.75				
30	.....do	1,266.50		1,266.50				
31	J. E. Shields	14.00						14.00
32	Streator and Third Vein Coal Co	606.22				606.22		
33	F. H. Ketcham	53.60				53.60		
34	Harry Clark	27.00				27.00		
35	C. E. Macy	77.00				77.00		
36	J. H. Scrogum	15.75			15.75			
37	August Peters	85.20			85.20			
38	M. S. Roster	17.55			17.55			
39	T. H. Thomas	2.29						2.29
	Total	4,618.51	20.78	2,343.25	746.64	1,088.32	361.23	58.29

Summary of expenditures for operating snag boats and dredge boats on Upper Mississippi River for fiscal year ending June 30, 1896.

Months.	Office expenses, superintendence and contingencies.	Care, repair, and operating snag boats and dredge boats.						Grand total.
		Labor.	Subsistence.	Fuel.	Expense.	Repairs.	Total.	
1895.								
July	$4.00	$1,453.66	.....	.....	.....	.....	$1,453.66	$1,457.66
August	4.25	1,455.00	$530.72	$1,025.70	$45.29	$114.04	3,170.75	3,175.00
September	16.00	1,481.67	496.28	674.06	339.14	112.20	3,103.35	3,119.35
October	255.50	1,485.00	366.53	747.56	104.01	18.00	2,721.10	2,976.60
November	87.84	741.81	57.21	451.49	.....	65.00	1,315.51	1,403.35
December	75.00	230.00	.....	.....	.....	.....	230.00	305.00
1896.								
January	.....	230.00	.....	.....	.....	26.00	256.00	256.00
February	7.75	230.00	.....	.....	.....	136.31	366.31	374.06
March	10.30	745.00	47.00	.....	.60	744.75	1,537.35	1,547.65
April	513.25	1,310.00	516.91	319.25	214.62	41.34	2,402.12	2,915.37
May	79.25	2,125.91	250.07	394.91	.....	1.31	2,772.20	2,851.45
June	20.78	2,343.25	746.64	1,088.32	361.23	58.29	4,597.73	4,618.51
Total	1,073.92	13,831.30	3,011.36	4,701.29	1,064.89	1,317.24	23,926.08	25,000.00

REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 1, 1896.

COLONEL: I have the honor to present my report on the operations of snag boats and dredge boats on Upper Mississippi River for the fiscal year ending June 30, 1896.

Operations of snag boat General Barnard.—On July 1, 1895, the *Barnard* left St. Paul, proceeding down river as far as Victory, where she arrived on the evening of the 2d. On this trip snags and other obstructions were removed at or near Rollingstone, River Junction, Root River, Bad Axe Bend, and Victory. From July 3 to July 19, the *Barnard* was employed in clearing the banks for shore protection, and otherwise assisting construction work in vicinity of Coon Slough. Leaving Lacrosse on the morning of July 20, ran to St. Paul, and leaving St. Paul on the 25th made an inspection trip to St. Louis, which point was reached on August 3. Leaving St. Louis on August 6, the *Barnard* worked up stream to St. Paul, arriving there August 30. On this trip snags and other obstructions were removed at or near Wilsons Grove, Missouri River, Alton, Squaw Island, Enterprise Island, Mound Landing, Iowa Island, Bolters Island, Dardenne Island, Cuivre Island, Sterling, Tisdales, Becks, Hickory Chute, Denmark Island, Cincinnati Landing, Armstrongs, Whitneys, Marion City, Sauerweins, Keithsburg, Bay Island, Comanche, Elk River, Dark Slough, Sand Prairie, Nine Mile Island, Spechts Ferry, Cassville Slough, Dakota, and Horse Shoe Bend. Between September 3 and October 1, a trip was made from St. Paul to St. Louis and return, on which trip work was done at 23 different localities. On the uorning of September 23 the *Barnard* struck a stump which had lodged in the cut near head of Des Moines Rapids, breaking 47 floor timbers and 1 bottom plank. She was immediately placed in the Dry Dock, was repaired, and came out on the afternoon of the 24th. Left St. Paul October 3, arrived at St. Louis October 17, and returning reached Nininger October 30. Leaving for down river on the same day, arrived at Des Moines Rapids Canal on November 5, and laid up for the winter. On this trip snags and other obstructions were removed at or near Montpelier, Keithsburg, Fort Madison, Tully Island, Stag Island, Hog Back, Dallas Chute, and Turkey Island. Property to be condemned was gathered from the various plants and stored at Middle Lock. October 9 to 12, drainage pipe was laid in Iowa Slough for the Flint Creek Levee. October 12 the boom at Lower Lock was put in the canal.

In 1896, the *Barnard*, having received considerable repairs during the winter and spring, came out of the Des Moines Rapids Canal on March 26, and proceeded to St. Louis, where she arrived on the 29th. On April 1 she left St. Louis for up river and reached St. Paul on April 30. On this trip snags and other obstructions were removed at or near mouth of Missouri River, Maple Island, Alton, Squaw Island, Becks Landing, Sandy Island, Slim Island, Hickory Chute, Mundys Landing, Armstrong Island, Marion City Bend, Fabius Island, Tully Island, Curtis Landing, Prairie Chute, Oquawka, Port Louisa, Dark Slough, Nine Mile Island, Cassville Slough, Wyalusing, West Newton, and many other localities. A wreck was removed at Maple Island,

and some dams were located and soundings made near Rock Island. On May 2 and 5 the *Barnard* made inspection trips from St. Paul to Franklin Avenue Bridge, Minneapolis, and on the 6th she left St. Paul for down river and arrived at St. Louis on the 26th May 11 to 14 the *Barnard* was at Galena Junction, taking soundings of river above the lock and below the lock in Harris Slough. On this trip snags and other obstructions were removed at or near Ferry Slough, Harris Slough, New Boston, Huron Island, Benton Island, Oquawka, Bludsoes, Curtis Island, Gregorys, La Grange, Mundys, Westport Island, Stag Island, and other points. From May 28 to June 3, the *Barnard* remained near St. Louis giving assistance to steamboats and barges injured or wrecked by the tornado of May 27. Left St. Louis May 4 for up river, reaching St. Paul June 20, and returning down river arrived at Rock Island June 30. On this trip snags and other obstructions were removed at or near Portage, Squaw Island, Dardenne Island, Turners, Slim Island, Curtis Landing, Huron Island, Keithsburg, Bay Island, Sabula, Apple River, Gordons Ferry, Nine Mile Island, Maquoketa Slough, Guttenberg Channel, Wyalusing, Redwing, and other points. An examination of harbor at East Dubuque was made on June 27.

Summary of operations of snag boat General Barnard for fiscal year ending June 30, 1896.

Snags removed	794
Leaning trees pulled back	495
Leaning trees felled	12,585
Wreck removed	1
Steamboats assisted	19
Miles run	9,157

Operations of snag boat J. G. Parke.—During the fiscal year the *Parke* was used as tow boat on construction work between Illinois and Missouri rivers.

Operations of towboat Alert and Dredge Vulcan.—From May 18 to end of June, dredge *Vulcan*, with towboat *Alert* as tender, was employed in widening the cut-off in Coon Slough. About 25,261 cubic yards of material was removed, at a cost of $3,182.91.

Operating snag boats and dredge boats on the Upper Mississippi River—Summary of operations from 1893 to 1896, inclusive (fiscal years).

Year.	Snag boat.	Snags removed.	Leaning trees felled and removed.	Leaning trees pulled back.	Steamboats assisted.	Miles run.	Remarks.
1893....	Barnard, Parke, and dredge Phœnix.	372	2,285	107	5	6,112	Barnard in snagging commission 166 days; 5 wrecks and 2 towheads removed. Trip to New Orleans with Mississippi River Commission.
1894....	Barnard	421	5,073	135	2	8,469	In snagging commission 218 days; 2 wrecks removed.
1895....	do	484	4,882	21	6	5,262	In snagging commission 166 days; 9 wrecks removed with assistance of Parke and dredges Phœnix and Vulcan.
1896....	do	794	12,585	232	19	9,157	In snagging commission 225 days; 1 wreck removed.
	Total, 1893–1896	2,071	24,825	495	32	29,000	
	Total, 1868–1892	6,815	39,169	784	163	98,795	
	Grand total, 1868–1896.	8,886	63,994	1,279	195	127,795	

RIVER NOTES.

The season of 1895 was one of continuous and very low water, but under the circumstances the channel was remarkably good, there being only a few badly obstructing bars. But owing to the low water, navigation—especially of packets—was slow. The rafters made but few complaints. In 1896 the river to the present time has remained high and very favorable to traffic. At several points it reached 13 feet on the gauges, but has now fallen to about 6 feet.

Available channel depths, in feet, at the worst bars at low stages in 1895, as found by the snag boat General Barnard.

Between St. Paul and Prescott (32 miles).—Stock Yards, 4; Robinsons, 4; Pine Bend, 4; Grey Cloud, 4; foot Nininger Slough, 4; above Prescott, 4.

Prescott to Lake Pepin (29 miles).—Trimbelle River, 3½ (later improved).

Reeds Landing to Winona (41 miles).—Wabasha, 3½; head Buffalo Chute, 3¾; above Fountain City, 4.

Winona to Lacrosse (31 miles).—Homer, 4; Mount Trempealeau, 3½; above Lamoille, 4; foot Blacksmith Slough, 4.

La Crosse to Prairie du Chien (72 miles).—Heytmans, 3½.

Prairie du Chien to Le Claire (153 miles).—Foot Cassville Slough, 4; Bunker Chute, 4; Specht's Ferry, 3½ (later improved); Finleys, 4; Maquoketa Slough, 4; Nine-Mile Island, 3½; Deadmans, 3½ (later improved); foot Bellevue Slough, 3¾; below Bellevue, 3¾; Sand Prairie, 4; Santa Fe, 4; above Albany, 3½; Comanche, 3½.

Rock Island to Keithsburg (58 miles).—Horse Island, 4; Dodges, 3¾; Montpelier, 3½; opposite Fairport, 3½; below Fairport, 3½; Hershey Chute, 4; above Muscatine bridge, 3½; Illinois Chute, 4; Turkey Island, 3½.

Keithsburg to Des Moines Rapids (60 miles).—Above Oquawka, 3¾; above Burlington, 3½; Lead Island, 3½; Polk Island, 3½; below Pontoosuc, 4; below Fort Madison, 3½.

Keokuk to Quincy (41 miles).—Lower Bludsoes, 3½; Wyaconda, 4; below Lagrange, 4.

Quincy to Clarksville (58 miles).—No crossing or bar as shoal as 4 feet.

Clarksville to Missouri River (85 miles).—McCoys Island, 4; Tisdales, 3¾; Reds Landing, 3½; below Reds, 4; opposite Grafton, 3½ (later improved).

List of wrecks between St. Louis and St. Paul which are or may become obstructions to navigation, with approximate dates of sinking, localities, etc.—Revised 1896.

When sunk.	Name.	Locality.	Remarks.
1870	A. J. Baker	Abreast of Gabaree Island; 1 mile above foot and 1,200 feet out from island.	May become an obstruction.
1849	Altona	In bar at Montgomery Towhead	Lies on rock bottom, and if towhead washes away will be in the way of navigation.
1859	Baltimore	do	Do.
1855	Badger State	Lying under wreck of Baltimore	Do.
1844	Unknown	About halfway between Wilsons Island and Rhodes Point.	May be in the way in the future.
1883	Barge	In crossing below Madison	An obstruction at present.
1895	do	Above head of Mobile Island	A serious obstruction.
1895	do	do	Do.
1880	Chapman	In chute between Islands 521 and 522.	May become an obstruction.
1880	Golden Eagle	In foot of chute opposita Martins Landing.	Do.
1874	Mollie McPike	Carrolls Field, opposite Turners Landing.	Partly removed by dredge Phœnix. In deep water, but snags may lodge on it and cause trouble.
1842	Amaranth	Head of Amaranth Island	May become an obstruction.
1842	Two barges	do	Do.
1859	Mohawk	Head of Clarksville Island	May get in the way.
1855	Dubuque	Above Mundys Landing	Liable to become a dangerous obstruction.
1850	Ferryboat	Bludsoes Crossing	In bar.
1880	Barge	Opposite lower sawmill at Keokuk	Can be hit at very low water.
1881	do	At Sauerweins Point	May be in the way soon.
	do	Just above Henderson River	In the way.
1853	Unknown	Below Benton Island	
1880	do	Near shore 1 mile below Edwards River.	Do.
1852	Flatboat	Near landing at Port Louisa	Near shore, but in the way.
1854	Dr. Franklin	Foot of Maquoketa Chute	Will soon be in the way.
1871	Hudson	1 mile below Guttenberg	In the way at low water.
1883	Barge	About 500 feet above Picayune Island.	In the way.
1895	do	Near foot of Coon Slough, at Island 124.	Near shore.
1891	do	Near Richtmans Landing	May get in the way.
1893	Ponton	Above Wabasha	Partly removed.

Locations of rocks between St. Louis and St. Paul which are or may become obstructions to navigation.

In Sawyer bend.
At and below the chain above St. Louis.
Old icebreaker outside of Louisiana waterworks.
Below Salt River.
Opposite middle of Orton Island.
In channel opposite foot of Lagrange Island.
Below Lagrange.
Near shore above Lagrange.
Rock patch near channel, about halfway between Gregorys Landing and Fox River.
Below Keokuk bridge.
At lower draw-rest and near west abutment of Keokuk bridge.
At Des Moines Rapids above canal to Montrose.
Rock bottom above Nauvoo Landing.
Above Nauvoo, in the crossing at Devils Island.
Opposite Fort Madison, abreast of the sawmills and steamboat landing.
At Pontoosuc and foot of Dallas Chute.
Above Burlington, at Drews Prairie.
Near head of Otter Island and above.
At mouth of Edwards River, near shore.
At and below Oquawka.
Below Keithsburg.
Below New Boston, Illinois side.
Opposite New Boston, in mid-river.
At Muscatine.
At Fairport.
At Montpelier.
First island below Buffalo.
Near shore at Buffalo.
Near shore above Spinneyville.
At and near the head of Smiths Island.
At Horse Island, above and opposite.
At Rock Island Rapids.
Near shore at Mount Vernon.
Near shore above Chimney Rock.
Above Reeds, at foot of Lake Pepin.
Below Grey Cloud Landing.
Near head of Robinsons Rocks, 50 feet from shore, pieces of ledge rock.
Bowlders at Pigs Eye.
In draw of Omaha bridge.
Rock patch near upper end of St. Paul.

Very respectfully, your obedient servant,

C. W. DURHAM,
Assistant Engineer.

Lieut. Col. W. R. KING, *Corps of Engineers, U. S. A.*

X 2.

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN MOUTH OF MISSOURI RIVER AND MINNEAPOLIS.

Under this head of appropriation are carried on, chiefly, works for the permanent improvement of through navigation. These works, in former reports fully described, consist of dams of rock and brush which close side chutes and properly contract the low-water channel, and of shore protections of the same materials. At several localities rock ledges and bowlders are being removed from the channel by drilling, blasting, and dredging, and two levees are now being built to restrain the river at high stages from overflowing the banks. Improvements at harbors and other designated localities are sometimes made under allotments as provided for in the various acts of Congress.

At the commencement of the fiscal year there was available the sum of $777,750.64, to which was added by river and harbor act of June 3, 1896, $200,000.

Work proceeded vigorously in 1895, but in 1896, to date, little has been accomplished, on account of high water. Under approved projects work of dam construction, shore protection, dredging, and removal of rock has been carried on during the past year by hired labor, competitive purchase of materials, and use of Government plant between St. Paul and Lake Pepin, between Reeds Landing and Genoa, at Rock Island Rapids, between Keithsburg and Nashville, between Keokuk and Quincy, between Quincy and Clarksville, and between the Illinois and Missouri rivers. Under formal contract between Glenhaven and Dubuque, between Dubuque and Clinton, between Rock Island and New Boston, between Hamburg and Cap au Gris, between Cap au Gris and the Illinois River, and also at the Flint Creek to Iowa River and Warsaw to Quincy levees.

The plant belonging to this appropriation received extensive repairs, and many pieces were added during the year.

Harbor at Burlington, Iowa.—No work was found necessary during the year, and there is an available balance of $3,094.38 remaining from the allotment in act of September 19, 1890.

Dredging Quincy Bay.—An allotment of $15,000 was made by river and harbor act of August 17, 1894, from funds appropriated by sundry civil act of August 18, 1894. A project was submitted October 26, 1894, and approved by the Secretary of War November 3, proposing to continue dredging under original project for the improvement of Quincy Bay to increase the depth at low water and to extend operations over portions of the bay as yet unimproved. Dredging, under formal contract with A. J. Whitney, begun April 9 was continued until November 6, 1895, when the contract was completed. Mr. Whitney's contract was approved January 17, 1895, and the time limit was December 31, 1895. There is an available balance for this work of $3,931.45, which is sufficient for fiscal year ending June 30, 1897. The river and harbor act of June 3, 1896, provides $15,000 for dredging the channel in Quincy Bay, which it is proposed to distribute over the three succeeding years.

Warsaw to Quincy.—The sundry civil act of March 2, 1895, allotted $85,500 for—

> Improving the navigation from the city of Warsaw to the city of Quincy, by preventing the water from overflowing the natural and artificial banks. * * *

A project was submitted March 30, 1895, and approved April 5, 1895. This project called for 602,643 cubic yards of earthen embankment and 1,200 cubic yards of riprap, at a cost of $85,500. A contract for the earthwork, approved June 15, 1895, was made with Casgrain & McDonald, said contract to be completed June 30, 1896. On account of high water and frequent rains, which have greatly retarded work, an extension to November 1, 1896, has been granted the contractors, and the contract will probably be completed by that time. The money appropriated will be sufficient to complete the work in accordance with the original project and survey report, and no further allotment is asked for.

Flint Creek to Iowa River.—The sundry civil act of March 2, 1895, allotted $85,000—

> To commence the work, under the direction of the Secretary of War, from the mouth of Flint Creek, in Des Moines County, State of Iowa, and running along the west bank of the river to the mouth of the Iowa River, with a view to improving the navigation by preventing the water from overflowing the natural and artificial banks along that part of the river, and deepening the channel, in accordance with the survey reported January 3, 1895, and the accompanying estimate.

The survey above mentioned says:

> The questions of outlets and interior drainage have not been considered. An earthen bank is estimated for, with a slope of 3 to 1 on the river side and 2 to 1 on the land side, with 4 feet width of crown, to reenforce and raise the natural bank where necessary, and following the transit lines as above described. The grade of the top of the bank is placed at 3 feet above high water of 1888, which will probably be of sufficient elevation to restrain any flood that is likely to occur. The average height of artificial bank will be about 8½ feet and its length 42 miles.
>
> The estimate calls for 1,855,193 cubic yards of earthwork, at 15 cents per yard, and, adding 10 per cent for contingencies, amounts to $305,000.

Under projects approved April 19 and June 28, 1895, a formal contract for 700,000 cubic yards of earthwork, including mile sections 1 to 18, was let to M. H. King, the lowest bidder, at 8.18 cents per cubic yard. This contract was approved September 7, 1895, and was to be completed June 30, 1896. Work under this contract was carried on with so little energy and progress that it was annulled April 7, 1896.

The uncompleted work in sections 1 to 8 was performed by various parties under competitive agreements, so that on May 1, 1895, this part of the work, amounting to about 180,000 cubic yards, was completed.

A contract for 450.000 cubic yards, comprising sections 9 to 18, was made with John A. O'Keefe & Co., approved June 6, 1896. This contract runs to May 31, 1897, and work was commenced in June, 1896. A contract, approved May 23, 1896, for 175,000 cubic yards of earthwork, sections 19 to 22, was made with Edward Callahan, which contract is to be completed December 31, 1896, and work on this contract is well under way. I would state that the original survey on which the estimate was based was preliminary, and that subsequent surveys for final location have reduced the length of proposed levee about 7 miles and the quantities about 110,000 cubic yards. It has also been found that the work can be performed at a much smaller price than at first estimated. These reductions will change the estimate from $305,000 to $250,000, and it is believed that this latter amount will cover the entire cost, not only of the earthwork, but of outlet drainage and necessary bank protection. The river and harbor act of June 3, 1896, contains an allotment of $75,000 for this work, so that $90,000 will be needed to complete it.

Harbor at Bay City, Wis.—The sundry civil act of March 2, 1895, provides:

> That * * * not to exceed one thousand dollars, may, in the discretion of the Secretary of War, be expended in the improvement of the channel to the harbor of Bay City, Wisconsin, at the head of Lake Pepin.

Under project approved June 12, 1895, and at a cost of $1,000, a pier of brush and rock, about 250 feet long, 10 feet wide on top and 8 feet in height above low water of 1864, was constructed by hired labor and use of Government plant.

The details of the above-mentioned improvements are given in the appended reports of assistants in local charge.

The obstructions to navigation in this river are very largely due to the immense quantities of silt carried into the channel from caving banks, and it is evident that one of the first considerations in any thorough and permanent improvement must involve the protection of these banks from erosion. One of the first questions to be solved, therefore, is, What is the nature and extent of the work required to prevent this erosion? A moderate amount of protection in the way of brush and stone has been found sufficient in most places, and in order to cover the greatest possible length of bank, with available means and in a given time, this protection should be made no heavier than is absolutely necessary. It is believed that the cost per linear foot need not average more than $2.35, and from as careful an estimate as can be made at this time it appears that the entire length of caving banks between St. Paul and the mouth of the Missouri River is 400 miles, of which 120 miles have been sufficiently protected. If the remainder of the caving banks, 280 miles, could be protected, the regulation of the low-water channel by wing dams could be readily accomplished and existing sand bars could be disposed of behind the dams and in the deep pools. It is evident that if this is to be done at all, sound business considerations require that it should be done systematically and continuously, which can only be done by adequate means, and the diversion of the appropriations to local harbor improvements and for the reclamation of overflowed lands can only result in delaying—and

perhaps defeating—the improvement of through navigation. It is believed that if this were once fully understood by the local interests that are now clamoring for small allotments the result would be beneficial.

Commercial statistics relating to the Upper Mississippi River accompany my report on "Operating snag boats and dredge boats on Upper Mississippi River." These statistics do not fully indicate the relations of this work to the interests of commerce and the general public. The influence which the river in an improved condition has upon freight rates must be taken as a measure of its importance. The amount of freight carried by railroads at river rates as a result of the river competition is very large during the season when navigation is practicable.

The improvement of the Upper Mississippi River has been carried on gradually, giving the river itself opportunity to assist in the formation of proper channels, and the work if carried to its fullest limits must extend over many years. It has not hitherto appeared desirable to prepare detailed plans for radical improvement, and the work has been prosecuted under general methods, with detailed plans for special localities, the approximate estimate being $20,000 per mile and the depth to be secured 4½ to 6 feet at low water. Project maps of the entire river in question are now being prepared from late surveys, and these, together with full estimates for the entire improvement, will be presented at an early day. It has been the custom to select for improvement, when funds are available, such localities as were at the time most detrimental to navigation, and such work has been spread along the entire length of the river, resulting in a considerable increase of the ruling navigable depth.

As an amount that can be profitably expended during fiscal year ending June 30, 1898, I present an estimate of $1,000,000.

Summary of expenditures for calendar year ending December 31, 1895, under appropriations for improving Mississippi River, "Ohio River to Minneapolis," applied to that portion of the river between the mouth of the Missouri River and Minneapolis.

Minneapolis to St. Paul (Lock and Dam No. 2)	$3,735.89
St. Paul to Lake Pepin	67,396.46
Harbor at Bay City	1,000.00
Reeds Landing to Genoa	117,701.59
Genoa to Prairie du Chien	28,327.22
Glenhaven to Dubuque	40,826.80
Dubuque to Clinton (two contracts)	31,088.44
Rock Island Rapids	68,364.55
Buoys on Rock Island Rapids	313.66
Muscatine to New Boston	41,682.28
Flint Creek to Iowa River Levee	16,426.78
Keithsburg to Nashville	62,644.62
Keokuk to Quincy	29,328.73
Warsaw to Quincy Levee	33,883.04
Quincy Bay	10,340.13
Quincy to Clarksville	93,600.59
Clarksville to Hamburg	41,721.54
Hamburg to Cap au Gris	25,087.68
Cap au Gris to Illinois River	48,403.83
Illinois River to Missouri River	86,149.01
Surveys and gauges	8,402.10
Purchase, construction, care and repair of plant	77,243.97
Total	933,668.91

NOTE.—In above statement retained percentages and delayed estimates on contracts December 31, 1895, are included.

Summary showing localities, amounts, and cost of regular construction works in 1895, between St. Paul and mouth of Missouri River.

Locality.	Method.	Material.		
		Rock.	Brush.	Total.
		Cubic yds.	*Cubic yds.*	*Cubic yds.*
St. Paul to Lake Pepin	Hired labor	44,243.4	81,268.2	125,511.6
Reeds Landing to Genoa	do	56,426.8	138,898.5	195,325.3
Keithsburg to Nashville	do	41,629.1	67,975	109,604.1
Quincy to Clarksville	do	65,233.7	100,902.2	166,135.9
Illinois River to Missouri River	do	66,561.2	102,862.7	169,423.9
Genoa to Prairie du Chien	Formal contract	23,851.2	20,705.5	44,556.7
Glenhaven to Dubuque	do	25,244.6	34,479.8	59,724.4
Dubuque to Clinton (1) *	do	21,030.5	18,974.8	40,005.3
Dubuque to Clinton (2)	do	9,196.4	9,451.2	18,647.6
Muscatine to New Boston	do	31,188.1	36,106.7	67,294.8
Keokuk to Quincy *	do	23,209.9	29,009.8	52,219.7
Clarksville to Hamburg	do	29,539.7	36,131.2	65,670.9
Hamburg to Cap au Gris *	do	30,926	22,021	52,947
Cap au Gris to Illinois River (1)	do	23,048.5	26,169.5	49,218
Cap au Gris to Illinois River (2)	do	17,451.8	17,604.5	35,056.3
Total		508,780.9	742,560.6	1,251,341.5

Locality.	Cost of work.	Average cost per cubic yard on barges.	Average cost per cubic yard for towing and putting in material.	Average cost per cubic yard for general superintendence, office expenses, and inspection.	Average cost per cubic yard for plant.	Average cost per cubic yard in place.
St. Paul to Lake Pepin	$66,708.41	$0.282	$0.202	$0.012	$0.036	$0.532
Reeds Landing to Genoa	97,341.90	.286	.167	.008	.037	.498
Keithsburg to Nashville	65,536.51	.349	.184	.014	.051	.598
Quincy to Clarksville	100,151.10	.331	.214	.014	.044	.603
Illinois River to Missouri River	94,378.35	.287	.218	.013	.039	.557
Genoa to Prairie du Chien	34,395.40	.....	.....	.055	.....	.772
Glenhaven to Dubuque	40,888.96	.....	.....	.037	.....	.685
Dubuque to Clinton (1) *	33,294.51	.....	.....	.054	.....	.832
Dubuque to Clinton (2)	11,510.95	.....	.....	.053	.....	.617
Muscatine to New Boston	41,735.93	.....	.....	.031	.....	.621
Keokuk to Quincy*	38,047.85	.....	.....	.022	.....	.729
Clarksville to Hamburg	41,800.72	.....	.....	.041	.....	.637
Hamburg to Cap au Gris *	41,713.55	.....	.....	.045	.....	.788
Cap au Gris to Illinois River (1)	30,096.93	.....	.....	.043	.....	.611
Cap au Gris to Illinois River (2)	18,537.87	.....	.....	.046	.....	.529
Total	756,138.97	.....	.....	.....	.....	.604

* Includes work of 1894, in which year the contracts were let.

Average cost per cubic yard in place, hired-labor work, $0.554.
Average cost per cubic yard in place, contract work, $0.684.
Hired-labor work: Average cost of towing and putting in material, 1891, $0.233; 1892, $0.295; 1893, $0.237; 1894, $0.214; 1895, $0.197.

Abstract of appropriations.

St. Paul to Des Moines Rapids:	
By act approved June 18, 1878	$250,000.00
March 3, 1879	100,000.00
June 14, 1880	150,000.00
March 3, 1881	200,000.00
By act passed August 2, 1882	250,000.00
By act approved July 5, 1884 (general improvement)	250,000.00
July 5, 1884 (applied to harbor, Lake City)	15,000.00
August 5, 1886	382,500.00
Minneapolis to Des Moines Rapids:	
By act of August 11, 1888	600,000.00
By act of September 19, 1890	500,000.00
Des Moines Rapids to Illinois River:	
By act approved June 18, 1878	100,000.00
March 3, 1879	40,000.00
June 14, 1880	100,000.00
March 3, 1881	175,000.00
By act passed August 2, 1882	200,000.00

Des Moines Rapids to Illinois River—Continued.	
By act approved July 5, 1884	$200,000.00
August 5, 1886	150,000.00
By act of August 11, 1888	200,000.00
By act of September 19, 1890	165,000.00
Ohio River to Minneapolis, applied to between Missouri River and Minneapolis:	
By act approved July 13, 1892	600,000.00
March 3, 1893 (sundry civil)	866,666.67
August 18, 1894 (sundry civil)	866,666.67
March 2, 1895 (sundry civil)	866,666.67
By act of June 3, 1896	200,000.00
Total	7,427,500.01

General statement showing net expenditures from the commencement of improvement to July 1, 1896, under various appropriations.

St. Paul to Des Moines Rapids	$1,560,323.17
Practical test of Adams Flume (St. Paul to Des Moines Rapids)	*22,176.83
Harbor at Lake City (St. Paul to Des Moines Rapids)	15,000.00
Minneapolis to Des Moines Rapids	1,096,905.62
Des Moines Rapids to Illinois River	1,330,000.00
Ohio River to Minneapolis (applied to "between mouth of Missouri River and Minneapolis")	†2,821,778.20
Total net expenditures	6,846,183.82
Balances July 1, 1896, Minneapolis to Des Moines Rapids	‡$3,094.38
Ohio River to Minneapolis	578,221.81
	581,316 19
Total appropriated	7,427,500.01

Net expenditures on the various sections of the river between Minneapolis and the Missouri River from commencement of improvement to July 1, 1896.

[Rock Island and Des Moines Rapids improvement not included.]

Locality.	Distance.	Amount.	Per mile.
St. Paul to Minneapolis	11	$70,669.96	$6,424.54
St. Paul to Prescott	32	660,714.53	20,647.33
Prescott to Lake Pepin	29	237,597.24	8,193.00
Harbors in Lake Pepin	.....	17,119.50	.....
Foot of Lake Pepin to Alma	12	341.439.26	28,453.27
Alma to Winona Bridge	29	486,219.00	16,766.17
Winona Bridge to La Crosse Bridge	31	241,382.13	7,786.52
La Crosse Bridge to McGregor Bridge	72	475,735.78	6,607.44
McGregor Bridge to Dubuque Bridge	59	178,289.11	3,021.85
Dubuque Bridge to Clinton Bridge	67	230,753.63	3,444.09
Clinton Bridge to Rock Island Bridge	40	357,663.79	8,941.60
Rock Island Bridge to Keithsburg Bridge	58	119,308.44	2,057.04
Keithsburg Bridge to Des Moines Rapids	60	610,044.60	10,167.41
Keokuk to Quincy Bridge	40	413,099.15	10,324.98
Quincy Bridge to Clarksville	60	718,669.50	11,977.82
Clarksville to Cap au Gris	43	491,362.12	11,427.02
Cap au Gris to Illinois River	27	272,042.84	10,075.66
Illinois River to Missouri River	25	233,726.00	9,349.04
Flint Creek to Iowa River Levee	.....	29,891.43	.....
Warsaw to Quincy Levee	.....	56,670.98	.....
Sny Levee	.....	56,728.99	.....
Quincy Bay *a*	.....	55,549.91	.....
Hamburg Bay	.....	10,000.00	.....
Surveys, gauges, and meter work	.....	185,350.96	.....
Snag and dredge boats and wrecking	.....	59,661.11	.....
Facilitating navigation through bridges	.....	2,072.72	.....
Practical test of Adams Flume	.....	27,176.83	.....
Plant at estimated value	.....	207,244.31	.....
Total	.....	6,846,183.82	.....

a Twenty-five thousand dollars additional expended at Quincy Bay under special appropriation.

* In addition to this amount Mr. Adams expended $13,000 appropriated by acts of August 2, 1882, and July 13, 1892.

† Of this amount $11,556.50 was expended in construction of Lock and Dam No. 2, between St. Paul and Minneapolis.

‡ Belongs to harbor at Burlington, Iowa.

Money statements.

MINNEAPOLIS TO DES MOINES RAPIDS.

July 1, 1896, balance unexpended and available belonging to harbor at Burlington, Iowa	$3,094.38

OHIO RIVER TO MINNEAPOLIS, APPLIED TO THAT PORTION OF THE RIVER BETWEEN THE MOUTH OF THE MISSOURI RIVER AND MINNEAPOLIS.

July 1, 1895, balance unexpended		$1,151,014.00
Amount appropriated by act of June 3, 1896		200,000.00
		1,351,014.00
June 30, 1896, amount expended during fiscal year		772,792.19
July 1, 1896, balance unexpended		578,221.81
July 1, 1896, outstanding liabilities	$13,809.43	
July 1, 1896, amount covered by uncompleted contracts	149,261.69	
		163,071.12
July 1, 1896, balance available		415,150.69
Amount that can be profitably expended in fiscal year ending June 30, 1898		1,000,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

Abstract of proposals received and opened by Lieut. Col. W. R. King, Corps of Engineers, at Rock Island, Ill., August 5, 1895, at 2 p. m., for "construction of levees between Flint Creek and the Iowa River."

[There is available for this work from appropriation of $1,500,000 made by the sundry civil act approved March 2, 1895, for "improving Mississippi River from mouth of Ohio River to Minneapolis, Minn.," under an allotment of $866,666.67 made by said act for "improving Mississippi River from mouth of Missouri River to Minneapolis," an allotment of $85,000, also made by said act, the project under this allotment having been approved April 18, 1895 (inclosure 7 of 10352), and a modification of same having been approved June 28, 1895 (inclosure 39 of 10352).]

No.	Name and residence of bidder.	Medium height for entire distance (700,000 cubic yards earthwork.)		Full height for about 17 miles (700,000 cubic yards earthwork.)	
		Per cubic yard.	Total.	Per cubic yard.	Total.
		Cents.		*Cents.*	
1	John Breheny & Sons, Keokuk, Iowa	12.25	$85,750	11.50	$80,500
2	McManus & Joyce, Keokuk, Iowa	11.50	80,500	11	77,000
3	John C. Lee, Council Bluffs, Iowa	16	112,000	16	112,000
4	Andrew T. Dankwardt, Burlington, Iowa	32.50	227,500	28.50	199,000
5	John J. McCaughey, Summit, Ill	12	84,000	12.74	89,180
6	Jones & Strickler, Keokuk, Iowa	11.38	79,660	10.38	72,660
7	Edwards & Walsh Construction Co., Davenport, Iowa	.....	.....	13	91,000
8	Paul Katz, Omaha, Nebr	10.70	74,900	9.70	67,900
9	Welcom J. Dull, Arcanum, Ohio	13.75	96,250	13.50	94,500
10	Casgrain & McDonald, Chicago, Ill	10.30	72,100	10.45	73,150
11	Murray Bros., Cedar Rapids, Iowa	20	140,000	17	119,000
12	Mallory, Cushing & Co., Omaha, Nebr	10	70,000	10.40	72,800
13	Nicholas Young, Burlington, Iowa	14	98,000	13.50	94,500
14	M. H. King, Des Moines, Iowa	8	56,000	8.18	*57,260
15	J. H. McTighe & Co., Memphis, Tenn	.....	.....	15	105,000
16	Ed. Phelan, Omaha, Nebr	.....	.....	14.50	101,500
17	Charles H. Breyman and George W. Tonson, Toledo, Ohio	16	112,000	14.50	101,500
18	Wm. F. Callahan, Omaha, Nebr	8.40	58,800	8.40	58,800
19	Martin, Jennings & Co., Memphis, Tenn	10.875	76,125	11.375	79,625
20	P. McDonnell, Duluth, Minn	10.50	73,500	9.90	69,300
21	Halvorson, Richards & Co., Minneapolis, Minn	11	77,000	11	77,000

* Recommended for acceptance; accepted, and written contract made.

Abstract of proposals received and opened by Lieut. Col. W. R. King, Corps of Engineers, at Rock Island, Ill., March 3, 1896, at 2 p. m., for "construction of dams and shore protections between Rock Island, Ill., and Muscatine, Iowa."

[There is available for this work from appropriation of $1,500,000 made by sundry civil act approved March 2, 1895, for "improving Mississippi River from mouth of Ohio River to Minneapolis, Minn.," under an allotment of $866,666.67 made by said act for "improving Mississippi River between mouth of Missouri River and Minneapolis," an allotment of $45,000 made by project approved January 24, 1896 (file number 13899.)].

No.	Name and residence of bidder.	30,000 cubic yards rock in place.		30,000 cubic yards brush in place.		Grand total.
		Per cubic yard.	Total.	Per cubic yard.	Total.	
				Cents.		
1	Albert Kirchner, Fountain City, Wis.....	$1.20	$36,000	29	$8,700	$44,700
2	Patterson Bros., Keokuk, Iowa.....	.70	21,000	19	5,700	*26,700
3	Mahoney & Stenger, Omaha, Nebr.....	1.18	35,400	22	6,600	42,000
4	A. J. Whitney, Rock Island, Ill.....	.95	28,500	16	4,800	33,300
5	A. B. Teasdale, Cassville, Wis	1.14	34,200	19	5,700	39,900
6	Jacob Richtman, Fountain City, Wis.....	1.00	30,000	23	6,900	36,900

*Recommended for acceptance; accepted, and written contract made.

Abstract of proposals received and opened by Lieut. Col. W. R. King, Corps of Engineers, at Rock Island, Ill., March 21, 1896, at 2 p. m., for "construction of levees between Flint Creek and Iowa River."

[There is available for this work from appropriation of $1,500,000 made by sundry civil act approved March 2, 1895, for "improving Mississippi River from mouth of Ohio River to Minneapolis, Minn.," under an allotment of $866,666.67 made by said act for "improving Mississippi River between mouth of Missouri River and Minneapolis," an allotment of $19,000 made by project approved February 7, 1896 (file number inclosure 40 of 10352).]

No.	Name and residence of bidder.	175,000 cubic yards earthwork.	
		Per cubic yard.	Total.
		Cents.	
1	P. McDonnell, Duluth, Minn.....	14	$24,500.00
2	McManus & Joyce, Keokuk, Iowa.....	9.98	17,465.00
3	McIvor & Butterfield, Marseilles, Ill	14.625	25,593.75
4	Gillespie, Leach & Tuttle, Spencer, Iowa.....	10.49	18,357.50
5	Walker Bros. & Vance, Troy, Ohio.....	11.70	20,475.00
6	Edward Callahan, Omaha, Nebr.....	8.99	*15,732.50
7	John W. Call, Elwood, Ind.....	10.90	19,075.00

*Recommended for acceptance; accepted, and written contract made.

Abstract of proposals received and opened by Lieut. Col. W. R. King, Corps of Engineers, at Rock Island, Ill., April 28, 1896, at 11 a. m., for "construction of levees between Flint Creek and Iowa River."

[There is available for this work from appropriation of $1,500,000 made by sundry civil act approved March 2, 1895, for "improving Mississippi River from mouth of Ohio River to Minneapolis, Minn.," under an allotment of $866,666.67 made by said act for "improving Mississippi River between mouth of Missouri River and Minneapolis," and a specific allotment of $85,000 also made by said act, an unexpended balance of $45,000 made available by project approved April 8, 1896 (file number, inclosure 45 of 12176).]

No.	Name and residence of bidder.	450,000 cubic yards earthwork.	
		Per cubic yard.	Total.
		Cents.	
1	Gillespie, Leach & Tuttle, Spencer, Iowa.....	12.87	$57,915
2	Nicholas Young, Burlington, Iowa	14	63.000
3	Cameron, McManus & Joyce, Keokuk, Iowa.....	11.99	53,955
4	Patrick McDonnell, Duluth, Minn.....	11	49,500
5	John J. McCaughey, Summit, Ill	14.94	67,230
6	Murray Bros., Cedar Rapids, Iowa.....	16	72,000
7	Michael H. King, Des Moines, Iowa	15	67,500
8	W. F. Callahan & Co., Omaha, Nebr.....	10.80	48,600
9	John A. O'Keefe & Co., Omaha, Nebr.....	10.39	*46,755

*Recommended for acceptance; accepted, and written contract made.

Comparative cost of materials, 1895.

Locality of delivery.	Rock, per cubic yard.		Brush, per cubic yard.		Earth-work, per cubic yard.
	In place.	On United States barges.	In place.	On United States barges.	In place.
Pine Bend to Lake Pepin	.....	.....	.....	$0.215	.....
Nininger	.....	$0.38	.....	.....	.....
Point Douglas	.....	.379	.....	.....	.....
Prescott to Red Wing	.....	.....	.....	.189	.....
Reeds Landing to Genoa	.....	.....	.....	.15	.....
Closing Dam No. 2 (sheet 18)	$1.00	.....	$0.25	.....	.....
Blacksmith Slough Dam	.....	.62	.....	.....	.....
Brownsville (within 20 miles of)	.....	.....	.....	.167	.....
Brownsville, or Warners Landing	.....	.4895	.....	.....	.....
Raft Channel (opposite Government light No. 2)	.....	.50	.....	.....	.....
Raft Channel (near head of)	.....	.55	.....	.....	.....
Raft Channel to Coon Slough	.....	.54	.....	.....	.....
Genoa	.....	.55	.....	.....	.....
Genoa to Prairie du Chien	1.00	.....	.14	.....	.....
Glenhaven to Dubuque	1.00	.....	.39	.....	.....
Dubuque to Clinton	1.00	.....	.14	.....	.....
Leclaire	.....	.53	.....	.....	.....
Do	.....	.50	.....	.....	.....
Do	.....	*1.90	.....	.....	.....
Muscatine to New Boston	1.12	.....	.13	.....	.....
Flint Creek to Iowa River Levee	†1.00	.....	†.20	.....	$0.0818
Keithsburg to Nashville	.....	.....	.....	.21	.....
Do	.....	.....	.....	.235	.....
Huron Island (vicinity of)	.....	.....	.....	.19	.....
Burlington	.....	.575	.....	.....	.....
Burlington (vicinity of)	.....	.....	.....	.21	.....
Do	.....	.59	.....	.....	.....
Do	.....	.64	.....	.....	.....
Burlington to Nauvoo	.....	.....	.....	.20	.....
Do	.....	.....	.....	.19	.....
Kempers Landing	.....	.575	.....	.....	.....
Pontoosuc and Dallas City (vicinity of)	.....	.535	.....	.....	.....
Warsaw to Quincy Levee, Bear Creek outlet	1.70	.....	.....	.....	.....
Warsaw to Quincy Levee, Bear Creek outlet (rubble masonry)	2.47	.....	.....	.....	.....
Warsaw to Quincy Levee, Hunt and Lima Lake District	.....	.....	.....	.....	.0895
Warsaw to Quincy Levee, Indian Grave District	.....	.....	.....	.....	.1095
Lagrange	.....	.....	.....	.25	.....
Quincy	.....	.62	.....	.....	.....
Quincy (vicinity of)	.....	.....	.....	.22	.....
Quincy Bay	.50	.....	.....	.....	.....
Quincy to Hannibal	.....	.....	.....	.22	.....
Quincy Bridge to Louisiana	.....	.....	.....	.22	.....
Do	.....	.....	.....	.21	.....
Quincy Bridge to Clarksville	.....	.....	.....	.21	.....
Do	.....	.....	.....	.20	.....
Do	.....	.....	.....	.215	.....
Do	.....	.....	.....	.22	.....
Bay Island	.....	.....	.....	.21	.....
Hannibal	.....	.55	.....	.....	.....
Do	.....	.50	.....	.....	.....
Do	.....	.535	.....	.....	.....
Do	.....	.53	.....	.....	.....
Do	.....	.525	.....	.....	.....
Hannibal, vicinity of	.....	.....	.....	.21	.....
Do	.....	.....	.....	.22	.....
Hannibal to Cincinnati Landing	.....	.....	.....	.2125	.....
Saverton, vicinity of	.....	.....	.....	.22	.....
Louisiana, 5 miles above	.....	.....	.....	.22	.....
Louisiana, vicinity of	.....	.....	.....	.20	.....
Do	.....	.....	.....	.22	.....
Louisiana	.....	.55	.....	.....	.....
Do	.....	.4775	.....	.....	.....
Clarksville to Hamburg	1.20	.....	.10	.....	.....
Hamburg to Cap au Gris	.94	.....	.15	.....	.....
Cap au Gris to mouth of Illinois River	.87	.....	.10	.....	.....
Grafton	.....	.43	.....	.....	.....
Alton, within 3 miles of	.....	.42	.....	.....	.....
Mouth of Missouri River, within 2 miles of	.....	.....	.....	.20	.....

* Slope wall stone.

† On bank.

REPORT OF MR. J. D. DUSHANE, SUPERINTENDENT.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., February 8, 1896.

COLONEL: I have the honor to submit the following report of operations under my direction for improving the Mississippi River between Minneapolis and Lake Pepin, for the calendar year ending December 31, 1895:

MINNEAPOLIS TO ST. PAUL.

Lock and Dam No. 2.—Under project approved October 9, 1894, a survey was made in 1894 for determining the exact site of Lock and Dam No. 2 and the land needed for these works and the approaches thereto. During 1895 considerable work on plans has been done, and negotiations for the purchase of the necessary lands and flowage rights have been in progress. The site for the dam abutment has been purchased, and arrangements have been completed for about 90 per cent of the flowage rights along both shores, all of which rights have been given for a nominal consideration. By action of the city council November 8, 1895, and of the board of park commissioners December 2, 1895, the proper officers of the city of Minneapolis, Minn., were authorized and instructed to convey to the United States lands for part of the lock site, and flowage rights to public lands along the entire length of the pool on the left bank of the river and to various lands and streets on the right bank within the limits of the pool. Negotiations are pending for other flowage rights.

The land desired for the remaining part of the lock site has not yet been acquired. It was proposed to acquire this land under condemnation proceedings, and the Department of Justice has instructed the United States district attorney to take the proper action. In hope of reaching a settlement out of court, at the request of the owners of the lands, the condemnation proceedings have been held in abeyance.

Up to the close of the calendar year no construction work has been begun, and it seems desirable that the commencement of this work be delayed until sufficient funds for the completion of the lock foundation be appropriated, the amount now available being insufficient for the purpose.

ST. PAUL TO LAKE PEPIN.

Under projects approved August 31, 1894, and April 17, 1895, work of building dams and shore protections and dredging channels was continued between St. Paul and Lake Pepin by hired labor and use of Government plant, and by dredging plant hired from private parties. Materials were purchased in open market.

Building dams and shore protections.—In the vicinity of Prescott, brush and rock Wing Dams 16 to 27 (sheet 8 *) and 6 to 11 (sheet 7) were built; Closing Dam 3 and Wing Dams 4 and 5 (sheet 7) were raised; and Wing Dams 1 and 2 were extended. To protect caving banks at the head and foot of Island 19 there were built 3,970 linear feet of shore protections, and 1,600 linear feet of caving bank was protected between Dams 23 and 24 (sheet 8). All protections were extended to the top of the bank and are about 45 feet in width.

Between Robinsons Rocks and Pine Bend, Wing Dams 15, 19, 31, and 53 to 58 (sheet 4) were built; Dams 6, 9, 10, 12, 16, 17, 18, and 18½ were raised and extended, and Dams 11, 14, 22, 23, 25, 26. 36, 37, and 42 were raised. The right bank at Pine Bend was protected from the head of the old shore protection upstream 1,600 feet.

At Island 15 Wing Dams 41, 54, 55, and 56 (sheet 5) were built; Dam 10 was extended; Dams 9, 13, 14, 15, 16, 18, 19, and 28½ were raised, and Closing Dam 1 was repaired. The right bank below Dam 49 was protected for a distance of 620 feet and width of 40 feet.

Dams 4 and 8 (sheet 6) and the shore protection in the vicinity of Hastings were slightly repaired. In the vicinity of Diamond Bluff Wing Dams 25 to 28 (sheet 9) were built across the crooked channel above the village, and Dams 30 to 32 were built to retain in place the extensive bar above. Wing Dams 33, 34, and 35 were built opposite the mouth of the Trimbelle River. The shore protection below Morgans Bar, left bank, was slightly repaired.

All new dams, 42 in number, total length 16,738 feet, were built at least 4.5 feet above low water of 1864. The work of construction was continuous from June 6 until November 9, 1895, on which latter date the entire fleet was laid up in the winter harbor at Boulanger Slough.

Towboat *Fury* and launch *Emily* were employed in towing materials on United States barges.

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* Sheet numbers are those of the general maps, survey of 1878–79.

Materials were purchased in open market, delivered on United States barges, at prices as follows: For brush, per cubic yard, 25, 21½, and 18⅞ cents; for riprap rock, per cubic yard, 44⅞, 38, and 37 9/10 cents.

Additional dams should be built in the vicinity of the stock yards, Hastings, Smiths Bar, Morgans Bar, and Sturgeon Slough; caving banks should be protected in the vicinity of Hastings, above Island 20, above Smiths Bar, and opposite Vermilion Slough.

Dredging.—In the vicinity of Diamond Bluff a gravel and bowlder patch, near the right bank, above Dam 18 (sheet 9), and the point of a gravel and bowlder bar projecting into the channel between Dams 14 and 24, were removed by dredge *Mogul*, tended by towboat *Remora*, under lease from Mr. C. H. Appleton. The plant was employed from May 28 to June 10, 1895, at $10 per hour while working on the upper patch and $8 per hour while working on the lower bar; it removed 3,818 cubic yards of material, which was delivered by dump scows to the pocket behind the dry bar above the village and between Dams 23 and 24.

The same plant was employed at $10 per hour for actual working time, from October 24 to November 2, in the vicinity of Grey Cloud Landing, removing a patch of gravel and bowlders which obstructed the channel abreast of Dams 51 and 52 (sheet 4). The material removed, 4,193.1 cubic yards, was deposited between dams.

Suction dredge No. 14 was put into service July 9, 1895, at Island 15, dredging a channel through a sand bar over which the available low-water depth did not exceed 2 feet. A channel 200 feet in width and 2,000 feet in length was dredged to a depth of at least 4 feet below low water of 1864. The material removed from this cut, 22,310 cubic yards, was deposited between the dams at the left bank and materially reduced the cost of Dams 54 and 55 (sheet 5), which were afterwards built.

The dredge was removed to Robinsons Rocks August 22, and several days were spent in making repairs and renewals of worn-out parts of the pump. At this locality 1,000 cubic yards of sand were pumped from the channel and deposited behind Dam 54 (sheet 4).

A very troublesome bar developed above the mouth of the Trimbelle River, at which point the dredge was employed from September 4 to 24 and October 14 to 29, removing 16,400 cubic yards of sand from the bar. Dam 34 (sheet 9), extending from the right bank, was built upon the deposit from this cut. A channel 300 feet in width and 4½ feet in depth at low water of 1864 was made through the bar.

From September 25 to October 3 the dredge was employed at Prescott dredging a channel through the bar immediately above the mouth of the St. Croix River. The sand removed from this bar, 3,190 cubic yards, was deposited near the right bank and entered largely into the construction of Dam 10 (sheet 7). This entire dredging plant was removed to winter quarters at Boulanger Slough on October 30.

Owing to some excessive repairs which became necessary during the working season, and the delays incident thereto, the cost per cubic yard of material removed has not been as low as is expected for future operations; but in consideration of the obvious advantages which this method of dredging affords in disposing of the materials dredged at all stages of water, and generally in such manner as to facilitate the formation of sand deposits between dams, or to enter largely into the construction of new dams, it is believed to be expedient and economical.

Summary of operations of suction dredge No. 14 for the season 1895.

In service	days..	90
Pump running	hours..	510
Time lost, making repairs	do....	46
Time lost on account of passing boats and rafts	do....	40
Time lost on account of transferring plant	do....	50
Coal used	tons..	276
Sand removed	cubic yards..	42,900
Sand put in dams	do....	5,700

During the season of 1896 dredging will probably be necessary at Pigs Eye, at the Stock Yards, at Robinsons Rocks, at Franklin Coulee, below Prescott, and below Diamond Bluff.

After proper establishment of harbor lines at St. Paul, considerable dredging may be advantageous within the harbor.

SURVEYS.

Surveys were made at Robinsons Rocks, Island 15, Prescott, and Diamond Bluff to indicate the progress of the season's work; and at Grey Cloud Landing to locate gravel bars and obstructing rocks. Below Nininger a comparative examination of Nininger Bar was made.

List of works constructed and repaired and of materials used during the season of 1895, between St. Paul and Lake Pepin.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
Sheet 4:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Closing dam 3, raised	.....	4.5	138.8	.....
Wing dam 6, extended	140	4.5	140.8	484.8
Wing dam 9, raised and extended	50	4.5	214.6	627.2
Wing dam 10, raised and extended	60	4.5	365	256
Wing dam 11, raised and repaired	.....	4.5	373.5	676.1
Wing dam 12, raised and extended	50	4.5	398	391.7
Wing dam 14, raised	.....	4.5	183.6	263.6
Wing dam 16, raised and extended	60	4.5	211.4	470.9
Wing dam 17, raised and extended	100	4.5	220.9	427.1
Wing dam 18, raised and extended	40	4.5	231.9	668
Wing dam 18½, raised and extended	25	4.5	208	461.9
Wing dam 22, repaired	.....	4.5	73.5	.....
Wing dam 23, raised	.....	4.5	211.8	308.7
Wing dam 25, repaired	.....	4.5	220.6	.....
Wing dam 26, repaired	.....	4.5	72.9	.....
Wing dam 36, repaired	.....	4.5	145.8	.....
Wing dam 37, repaired	.....	4.5	74.4	.....
Wing dam 42, raised	.....	4.5	310.6	537
Wing dam 15	130	4.5	179.4	698.9
Wing dam 19	377	4.5	264	983.9
Wing dam 31	169	4.5	112.5	209.5
Wing dam 53	790	4.5	671.5	1,467.5
Wing dam 54	100	4.5	111.8	462.4
Wing dam 55	244	4.5	184.8	570.4
Wing dam 56	443	4.5	844.9	2,308.5
Wing dam 57	238	4.5	287.4	500.7
Wing dam 58	316	4.5	430	899.3
Shore protection at Pine Bend	1,600	.....	2,780.4	1,904.5
Sheet 5:				
Closing dam 1, repaired	.....	4.5	241.3	165
Wing dam 9, repaired	.....	4.5	70.5	.....
Wing dam 10, extended	200	4.5	358	689.3
Wing dam 13, repaired	.....	4.5	78.3	.....
Wing dam 14, repaired	.....	4.5	78.4	.....
Wing dam 15, repaired	.....	.....	76	.....
Wing dam 16, repaired	.....	.....	63.2	.....
Wing dam 18, repaired	.....	.....	41.4	.....
Wing dam 19, repaired	.....	.....	67.8	.....
Wing dam 28½, repaired	.....	.....	42	.....
Wing dam 41	310	4.5	302.8	704.1
Wing dam 54	325	4.5	357.3	530.7
Wing dam 55	435	4.5	445.4	1,157.7
Wing dam 56	300	4.5	356.6	611.7
Shore protection below dam 49	620	.....	895.8	535.7
Sheet 6:				
Wing dam 4, repaired	.....	.....	86	.....
Wing dam 8, repaired	.....	.....	57.8	.....
Shore protection, vicinity of Hastings, repaired	.....	.....	151	.....
Sheet 7:				
Wing dam 1, extended	200	4.5	154.4	746.8
Wing dam 2 extended	80	4.5	339.9	1,328.7
Closing dam 3, raised	.....	6	579.2	984.4
Wing dam 4, raised	.....	4.5	431.2	555.2
Wing dam 5, raised	.....	4.5	254.8	279.5
Wing dam 6	300	4.5	430.8	839.8
Wing dam 7	339	4.5	431.7	1,249.7
Wing dam 8	285	4.5	388	605
Wing dam 9	188	4.5	248.5	613
Wing dam 10	190	4.5	241.9	238
Wing dam 11	113	4.5	251.8	758.3
Shore protection, head of Island 19	1,020	.....	2,754	1,448.4
Shore protection, foot of Island 19	2,950	.....	4,903.9	3,804.5
Sheet 8:				
Wing dam 15	618	4.5	1,183.5	2,271.2
Wing dam 16	708	4.5	1,253	2,765.2
Wing dam 17	860	4.5	1,455.3	2,711
Wing dam 18	829	4.5	1,207.1	2,209.2
Wing dam 19	740	4.5	1,049.1	2,778
Wing dam 20	611	4.5	813.7	1,972.6
Wing dam 21	320	4.5	457	792.1
Wing dam 22	275	4.5	698.3	1,888.4
Wing dam 23	150	4.5	305.9	603.1
Wing dam 24	170	4.5	337.6	1,063.6
Wing dam 25	370	4.5	659.8	2,111
Wing dam 26	535	4.5	925.6	2,315.9
Wing dam 27	543	4.5	811.1	2,154.7
Shore protection between dams 23 and 24	1,600	.....	2,609.7	1,781.3

List of works constructed and repaired and of materials used during the season of 1895, between St. Paul and Lake Pepin—Continued.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
Sheet 9:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Wing dam 25	437	4.5	316.3	1,422.5
Wing dam 26	510	4.5	872.2	3,429.6
Wing dam 27	542	4.5	917.5	3,858
Wing dam 28	411	4.5	750.3	2,656.7
Wing dam 30	484	4.5	292.8	1,466.9
Wing dam 31	519	4.5	354.2	928.3
Wing dam 32	334	4.5	431.3	1,236.1
Wing dam 33	475	4.5	674.1	3,345.1
Wing dam 34	375	4.5	352.7	791.2
Wing dam 35	330	4.5	498.2	1,292
Shore protection, Morgans Bar, repaired	.....	.....	173.9	.....
Total	.....	.....	44,243.4	81,268.2

Financial statement for work of building dams and shore protections between St. Paul and Lake Pepin for the calendar year 1895.

Amount expended in field during calendar year 1895 (from distribution sheets)		$60,656.79
Add quota of general superintendence and office expenses		1,536.14
Add for use and deterioration of plant		4,515.48
Total		66,708.41
Material put in works:		
Rock	cubic yards	44,243.4
Brush	do	81,268.2
Total		125,511.6
Average cost per cubic yard:		
On barges		$0.282
For towing and putting in place		.202
For general superintendence and office expenses		.012
For plant		.036
Average cost per cubic yard in place		.532

Financial statement for dredging between St. Paul and Lake Pepin for the calendar year 1895.

By use of hired plant:		
Amount paid contractor		$2,091.00
Add quota of general superintendence and office expenses		52.27
Total		2,143.27
Material dredged	cubic yards	8,011.1
Average cost per cubic yard of gravel and bowlders removed		$0.267
By suction dredge No. 14:		
Amount expended in the field during calendar year 1895 (from distribution sheets)		$2,985.62
Add quota for general superintendence and office expenses		74.64
Add for use and deterioration of plant		507.45
Total		3,567.71
Material removed	cubic yards	42,900
Average cost per cubic yard of sand removed		$0.083

HARBOR AT BAY CITY, WISCONSIN.

The sundry civil act of March 2, 1895, in making appropriation for improvement of Mississippi River from mouth of Missouri River to Minneapolis, provides:

"That * * * not to exceed one thousand dollars may, in the discretion of the Secretary of War, be expended in the improvement of the channel to the harbor of Bay City, Wisconsin, at the head of Lake Pepin." * * *

Lieutenant-Colonel Mackenzie, in his project of June 3, 1895, approved by the Secretary of War June 12, 1895, says:

"To improve the channel by dredging was found to be impracticable without a very large expenditure of money. It was thought best, with the sum available, to construct an earthen embankment about 300 feet long, running directly out into the lake from the village front, and to protect this bank with riprap or paving. Boats can use this pier as a landing and also as a protection harbor or breakwater."

The work of improvement of the harbor was begun October 7 and completed October 23, 1895, being performed by hired labor and use of Government plant. It was intended to dredge the harbor and with the material thus obtained construct the body of a breakwater and to riprap the surface. The material composing the bottom of the bay was found to be unsuitable for the purpose, however, and a brush and rock breakwater was therefore built. This pier is located about 800 feet westerly from the foot of Wabash avenue, and is 250 feet in length, 8 feet in height (above low water of 1894), and 10 feet wide on top. In cross section the pier has a vertical harbor face and a sloping lake face of 2 on 1, the latter face and the top being carefully covered with riprap rock 2 feet in thickness. The available low-water depth in the harbor is at present 3 feet.

The total cost of pier at Bay City was $1,000.

I take pleasure in mentioning the careful supervision which Mr. H. E. Clark, overseer, has given in the immediate charge of field operations.

Very respectfully, your obedient servant,

J. D. DUSHANE,
United States Superintendent.

Lieut. Col. W. R. KING,
Corps of Engineers, U. S. A.

REPORT OF MR. W. A. THOMPSON, SUPERINTENDENT.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., January 18, 1896.

COLONEL: I have the honor to submit the following report of operations for improvement of the Mississippi River in the division in my local charge for the calendar year ending December 31, 1895:

REEDS LANDING TO GENOA.

The improvement of this section of the river, 95 miles in length, by dredging and the construction of dams and shore protection, was carried on under projects approved August 31, 1894, and April 17, 1895.

Blacksmith Slough.—Operations for the completion of work commenced in vicinity of Blacksmith Slough and Homer Chute during 1894 were resumed January 14, 1895, material being hauled over the ice by teams to points where needed, but owing to the weakness of the ice this method was discontinued February 28, 1895, and the work completed in the ordinary manner—by the use of boats and barges—during month of May, 1895.

Vicinity of Coon Slough.—The greater part of the work done during the season was in vicinity of Coon Slough, below Brownsville. The river at this point divided into two parts, Coon Slough running down the east side of Island No. 120 and Raft Channel down the west side of same island, the two bodies of water uniting about 12 miles below Brownsville, nearly opposite Genoa. Above Island 120 was a very large and dry sand bar. All the water running down the east side of this bar went into Coon Slough, and all that went to the west side was divided below the bar, a portion of it going down Raft Channel and the remainder passing between the head of Island 120 and the bar above into Coon Slough. During high stages of water boats and rafts ran Raft Channel, it being straighter and shorter than Coon Slough, but at medium and low stages all navigation was through Coon Slough, which had a

greater navigable depth, but was crooked and extremely difficult to run, especially at the head, where there were two abrupt turns through which it was almost impossible to guide a raft without striking the banks and sustaining more or less damage. Large packets also experienced considerable trouble at this point, where they were oftentimes compelled to back through, the turn being too short to allow of the boats being guided "head on." Big Bend, near the middle of Coon Slough, has for years been a difficult point to navigate, and many "break-ups" to rafts have occurred on account of the sharp turn in the channel at this place.

Owing to the great expense involved in the improvement of this part of the river, the work has been put off from year to year in hopes that the river would regulate itself and perhaps do away with the necessity of performing work here at all; but instead of getting better the channel became narrower and more crooked each succeeding year, until, in the low-water season of 1894, it was almost impossible to enter Coon Slough at the head without breaking up or getting aground. It was without doubt the most difficult place to navigate on the upper river. Many of the navigators were of the opinion that Coon Slough should be closed with a dam and Raft Channel regulated for navigation, but from the map of Raft Channel it will be seen that the large body of sand which would of necessity have to be carried down to the main river in vicinity of Genoa made the adoption of such a plan impracticable. On the other hand, there was the large field of sand above Coon Slough that would have to be moved in order to gain a good entrance at the head of the slough. This sand if carried into the slough would have interfered greatly with navigation, and would in all probability have stopped it entirely, for a time at least. To provide against this contingency, after a cut had been made through the bar by means of railroad scrapers and a dredge, for the purpose of letting the water through and thereby securing the aid of the current in moving the sand, a series of wing dams were constructed above Raft Channel, from the Minnesota shore to the bar, resulting in lowering the water surface below the dams enough to create a strong draft into Raft Channel, and cause the direction of the current to change from Coon Slough to Raft Channel. Wing dams were then built from the Wisconsin shore, above the head of Coon Slough, in such a manner as to force a large body of water through the ditch with great velocity, thence across the head of Island 120 into Raft Channel, where nearly all the sand carried with the current was deposited out of the way. Later on, when the cut widened sufficiently to permit the passage of boats and rafts, the old channel was closed and all the water forced through the new channel. This made the draft across the head of Island 120 too strong for rafts to enter Coon Slough with safety, and to remedy this Raft Channel was closed with a dam, consequently all the sand moved from the bar was carried into Coon Slough and for a time threatened to cause trouble, but the swift current gradually moved the sand into deeper water, and no further trouble is anticipated on this account. At the close of the season there was a straight permanent channel, 400 feet wide and at least 6 feet deep at low stages of water, above and at the head of Coon Slough. About 1,170,000 cubic yards of sand were removed from this bar.

The entrance at head of Coon Slough was straightened and widened by the removal by dredge, of the northeast corner of Island 120.

At Big Bend, about halfway through Coon Slough, a new channel was excavated through the neck of land that caused Big Bend, and a closing dam was built across the old channel.

By closing Raft Channel all the water in the river was forced through Coon Slough, causing a very rapid current, as the slough averages only about 800 feet in width. The banks in the concave bends began cutting badly, and to stop this all these banks were protected in the usual way with rock and brush. When the work of dredging in Coon Slough had been completed the dredge was employed about two weeks in the removal of two small wing dams and a rock patch below Winona, as also a barge wreck below Richtmans. The dredge was then laid up for the winter in Fountain City Bay.

Following are the details of the work accomplished during the season:

(*a*) *Construction of dams and shore protections.*—The first work undertaken was the completion of the unfinished work of 1894 in vicinity of Homer Chute and Blacksmith Slough. As rock and brush were available on the bank at a short distance from the work, under agreements made in 1894, it was considered advisable to complete these dams while the river was frozen over and material could be transported over the ice on sleighs to points where needed, this being a very economical method of constructing dams where the water is shoal and the material does not have to be hauled more than 1 mile. The work performed by hired labor, was commenced January 14, 1895, and discontinued February 28, 1895, when the ice commenced to break up. Blacksmith Slough Closing Dam No. 1 (sheet 18), and shore protection above same, and Wing Dams 43, 51, and 52, were extended and raised. One new wing dam, No. 62, was built to a length of 125 feet, but not completed, and a break in the Wisconsin shore, 400 feet above Closing Dam 2 (sheet 19), was closed.

List of works constructed and repaired, and of materials used, during January and February, 1895, in vicinity of Blacksmith Slough and Homer Slough.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
Sheet 18:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Closing dam 1, extended	227	4	1,065.3	2,099.4
Wing dam 43, extended	660	4	1,053.1	2,594.2
Wing dam 51, raised	.....	4	338.1	229.2
Wing dam 52, extended	40	4	41.4	34.6
Wing dam 62	125	4	111.7	592.2
Shore protection above dam 1 (Wisconsin shore)	225	.....	177.6	444.5
Sheet 19:				
Shore protection above dam 2 (Wisconsin shore)	60	.....	124	285.7
Total	1,337	.....	2,911.2	6,279.8

Financial statement for work of building dams and shore protections in vicinity of Blacksmith Slough and Homer Chute, performed by hired labor during January and February, 1895.

Amount expended in the field during calendar year 1895 (from distribution sheets)		$4,513.17
Add quota of general superintendence and office expenses		80.34
Total		4,593.51
Material put in works:		
Rock	cubic yards	2,911.2
Brush	do	6,279.8
Total	do	9,191
Average cost per cubic yard:		
On bank		$0.319
For hauling and putting in place		.172
For general superintendence and office expenses		.009
Average cost per cubic yard in place		.500

February 15, 1895, an agreement was entered into with H. F. Murr, of Fountain City, Wis., for the repair of Closing Dam No. 2 (sheet 18), at $1 per cubic yard for rock in place, and 25 cents per cubic yard for brush in place. This work was commenced February 23, 1895, and discontinued before completion, on account of the weakness of the ice, February 26, 1895; 149.2 cubic yards of rock and 331.1 cubic yards of brush, making a total of 480.3 cubic yards, were put in place, at a cost of $231.98; an average cost of $0.483 per cubic yard in place.

Work of building dams and shore protections, by hired labor and use of Government plant, was resumed May 1, 1895, towboat *Alert* and launches *Ada* and *Elsie* being used for towing. Material, loaded on barges, was purchased as follows: In open market, under public notice of ten days and sealed proposals, lime rock at 45.95, 50, 54, and 55 cents per cubic yard; brush at 16⅜ and 19¾ cents per cubic yard. In open market, at a price less than that fixed by competition, brush at 15 cents per cubic yard. In addition to material purchased as above stated, a large amount of rock was quarried and loaded by days labor. During the season of 1895, 1,602.3 cubic yards of brush, left on hand at close of season of 1894, was used.

The first work done, consisting of the repair of Blacksmith Slough Closing Dam and the shore protection above Closing Dam 2 (sheet 19), was commenced May 1 and completed May 6, 1895.

On May 8, 1895, the fleets harbored at La Crosse and Fountain City were taken to the head of Coon Slough, where the construction of three wing dams, Nos. 1, 2, and 3 (sheet 23), from Minnesota shore above Raft Channel was commenced. These dams, aggregating 2,590 feet in length, were completed in July. Six wing dams, No. 53 (sheet 22) and Nos. 4, 5, 6, 7, and 9 (sheet 23), aggregating 6,740 feet in length, all from the Wisconsin shore above head of Coon Slough, were commenced in May and completed in August. Wing Dam 8 (sheet 23), 290 feet in length, is built from left bank

of Coon Slough, about 1,000 feet below the "cut-off" at Big Bend. Closing Dam 10, 1,200 feet in length, was built across Raft Channel during June and July. Closing Dam 11, built in August, closes Bullet Chute, and is 140 feet long. Closing Dam 12, built in October, across Big Bend in Coon Slough, is 800 feet long. These dams, with the exception of Wing Dam 5 and Closing Dam 11, which are 6 feet above low water of 1864, are all 5 feet above low water of 1864.

Seven pieces of shore protection, A to G, inclusive, were built in and above Coon Slough from May to November, as follows: Shore protection A, on east side of Island 118, begins at a point 3,360 feet above Dam 1 (sheet 23) and extends downstream to same dam. Shore protection B, on Wisconsin shore of Coon Slough, begins at a point 3,950 feet above foot of Crosby Slough and extends downstream to foot of said slough. Shore protection D, on right bank of Coon Slough, begins at head of Island 120 and extends down the east side of the island a distance of 7,150 feet, closing Below and Deadmans sloughs. Shore protection E, on left bank of Coon Slough, begins at Bullet Chute and extends down the west side of Island 121 a distance of 1,900 feet. Shore protection F, on right bank of Coon Slough, begins at the foot of Deadmans Slough and extends downstream 4,120 feet to the head of Island 122, closing Middle Slough. Shore protection G, on right bank of Coon Slough, begins nearly opposite Warners Landing and extends downstream; 3,000 feet of this shore protection has been completed, the remainder to be built next season.

The total length of wing dams built is 9,620 feet; of closing dams, 2,140 feet, and of shore protection, 26,030 feet.

Operations were discontinued for the season November 2, and the entire fleet was laid up for the winter in Fountain City Bay.

Works of improvement should be made in vicinity of Alma, below Mount Vernon, below Dresbach, and in vicinity of La Crosse Railroad Bridge. The following series of dams should be extended: Right bank below Chimney Rock; opposite Fountain City; opposite Van Gorders Quarry; below Chicago, Burlington and Northern Railroad Bridge at Winona; in vicinity of La Plume Island, and opposite Picayune Chute. Shore protections should be extended opposite Island 29, opposite Crats Island, at Islands 55 and 58, Richmond Island, Islands 93 and 98, Grand Island, Broken Arrow Island, Islands 113 and 116, and in Coon Slough. Shore protections should be built below Dam 21 (sheet 15), above Buffalo Slough, opposite Island 47, above Minneiska, opposite Island 55, at Island 63, at Winters Landing, and below Root River.

Closing dam across Rollingstone Slough should be raised.

List of works constructed and repaired, and of materials used, during season of 1895, between Reeds Landing and Genoa.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
	Feet.	*Feet.*	*Cu. yds.*	*Cu. yds.*
Sheet 18: Closing dam 1 repaired	.....	.....	323.9	689
Sheet 19: Shore protection above dam 2 (Wisconsin shore) repaired	.....	.....	68.9	195.1
Sheet 22: Wing dam 53	820	5	1,015.4	3,974.4
Sheet 23:				
Wing dam 1	380	5	596.4	1,865.1
Wing dam 2	785	5	1,263.5	4,752
Wing dam 3	1,425	5	2,235.7	8,543.9
Wing dam 4	915	5	588.6	2,493.4
Wing dam 5	1,355	6	4,635.7	13,665.3
Wing dam 6	1,630	5	1,498.2	6,259.5
Wing dam 7	1,800	5	2,352.8	12,509
Wing dam 8	290	5	388.8	1,773.4
Wing dam 9	220	5	946.2	2,841.8
Closing dam 10	1,200	5	2,987.1	10,829.1
Closing dam 11	140	6	649.4	2,104.3
Closing dam 12	800	5	1,873.3	9,406.5
Shore protection A (east side of Island 118)	3,360	.....	2,849.6	3,961.6
Shore protection B (opposite head of Island 120)	2,550	.....	3,234.5	2,304.6
Shore protection C (Wisconsin shore, above foot of Crosby Slough)	3,950	.....	3,361	8,548.6
Shore protection D (head and east side of Island 120)	7,150	.....	11,345.2	16,650
Shore protection E (head and west side of Island 121)	1,900	.....	3,137.5	5,733.1
Shore protection F (opposite foot of Island 121)	4,120	.....	6,528.8	13,547.6
Shore protection G (opposite Warners Landing)	3,000	.....	4,546.3	6,311.2
Total	.....	.....	56,426.8	138,898.5

Financial statement for work of building dams and shore protections between Reeds Landing and Genoa, performed by hired labor during season of 1895.

Amount expended in the field during calendar year 1895 (from distribution sheets)		$88,699.45
Less amount expended in erection of cable hoist at Britts Landing	$249.29	
Less amount expended in dredging at elbow in Coon Slough	279.04	
		528.33
Total		88,171.12
Add cost of material on hand January 1, 1895		316.46
Add quota of general superintendence and office expenses		1,582.71
Add for use and deterioration of plant		7,271.61
Total		97,341.90
Material put in works:		
Rock	cubic yards	56,426.8
Brush	do	138,898.5
Total	do	195,325.3
Average cost per cubic yard:		
On barges		$0.286
For towing and putting in place		.167
For general superintendence and office		.008
For plant		.037
Average cost per cubic yard in place		.498

(*b*) *Dredging.*—Work of excavating a new channel through the high part of the dry bar above Coon Slough, by means of teams and scrapers, was commenced February 11, 1895, but was temporarily suspended February 25, 1895 on account of the water rising and submerging the bar. The river having receded sufficiently, operations were resumed April 9 and continued to May 15, 1895. The high part of the bar, on a surface average 1,700 feet in length and 200 feet in width, was removed to a depth of about 3½ feet and the material deposited on the side of the proposed channel. The removal of this material enabled the dredge to cut her way through the bar by casting the dredged sand to one side. The northeast corner of Island 120, for a length of 750 feet and average width of 75 feet and depth of 7 feet, was removed with scrapers, bringing it to a level with the water surface. During the latter part of May the scrapers were used in excavating for a new channel across Big Bend in Coon Slough. About 62,000 cubic yards of material were removed with the scrapers, at a cost of $6,326.24, or an average cost per cubic yard of $0.102.

On April 6, 1895, dredge *Vulcan* was towed from the winter harbor in Fountain City Bay to the dry bar above Coon Slough, where, on April 8, the work of dredging a new channel through the bar was commenced. Towboat *Alert* acted as tender for the dredge and assisted in the removal of the sand by washing the lower side of the bar into deep water with her wheel, which method proved very successful. A channel 1,700 feet in length, 100 feet in width, and about 5 feet deep at low water was cut through the bar. As it was impossible to remove the material in dump boats it was cast on the sides of the proposed channel. On May 11 the dredge commenced removing the northeast corner of Island 120, where the upper portion had been taken away with scrapers. This section was removed to a grade of 5 feet below low water. As the dredge had to be taken away at different times to widen the old channel at the head of Coon Slough, and to remove deposits of sand from the new channel, the work at Island 120 was not completed until May 31. June 1 the dredge was taken to Big Bend in Coon Slough, where she was employed in cutting a new channel through the neck of land causing Big Bend until September 7, with the exception of three weeks spent in keeping the channel at the head of the slough open and in dredging in front of the loading dock at Britts Landing Quarry. The cut at Big Bend is 800 feet long, 400 feet wide at the head, and 250 feet wide at the lower end.

On September 9 the dredge was towed to Winona, where she was employed until September 16 in removing two small wing dams, Nos. 44 and 45 (sheet 18), below the railroad bridge, and a small patch of rock above same bridge. The dredge was then taken to Richtmans Landing, where the wreck of an old rock barge was removed from the channel. September 18 and 19 the dredge was engaged in dredging in front of the boat ways at Fountain City. Preparations were then made to haul the dredge out on the ways and the crew was discharged. Towboat *Alert*

returned to Coon Slough and was employed during remainder of season towing rock and brush.

Material dredged during the season:

Number of cubic yards removed in dump boats	83,456
Estimated number of cubic yards "cast"	52,065
Total number of cubic yards dredged	135,521
Cost of dredging, including office expenses and plant charges	$18,868.49
Average cost per cubic yard	.139

QUARRYING ROCK AT BRITTS LANDING.

On May 4, 1895, the work of opening a quarry at Warners Landing, Wis., was commenced, but after spending four days in uncovering the rock it was found impracticable to continue work in this quarry. On May 9, 1895, a new site was chosen for a quarry on top of the bluff at Britts Landing, Wis., and the work of developing this quarry, building roads to the river bank, and quarrying rock was carried on by hired labor and use of Government plant until the close of the season. A quarry has been uncovered with a face of about 900 feet and an average depth of 75 feet (front to back). The expense of opening this quarry and building the necessary roads and docks was very large, but the quarry is now in such condition that rock may be delivered on barges, by means of cable-hoist transportation, for a much lower figure than that heretofore paid to contractors.

A lease of the ground on which the quarry is located, covering a period of five years if required, from August 1, 1895, was procured from the owners of the land at an annual rental of $300.

Following are the amounts quarried per month and the average cost per cubic yard loaded on barges:

Month.	Number of cubic yards.	Average cost per cubic yard.
May	693.5	$2.2698
June	2,799.2	.8409
July	4,482.7	.6691
August	9,138.4	.6199
September	10,207.6	.5882
October and November	10,807.6	.5392
Total	38,129	.6409

SURVEYS.

A party in charge of Mr. Louis Shaw was employed during the early part of the season in making surveys and examinations of the Mississippi River at Chimney Rock and Homer Chute to show the results of improvement work done during the previous season. April 15, 1895, a party of eleven men was organized to make a survey of the river from the Chicago, Milwaukee and St. Paul Railroad Bridge at La Crosse to 2 miles below Brownsville. Upon the completion of this work, May 14, 1895, the party was taken to the head of Crooked Slough, and a survey of the river from that point to Island 182, about 3 miles below Clayton, Iowa, was commenced. The field work on this survey was completed July 13, 1895, and the party disbanded. During the latter part of October a survey of the river was made between Brownsville, Minn., and Britts Landing, Wis., to show the results of the season's improvement works. The notes of these surveys were platted in this office from August to December, 1895. The total number of miles of river surveyed is 67.2, and the cost of the surveys, exclusive of plant charges and charges for general superintendence and office expenses, is $2,869.32.

CARE, REPAIR, AND CONSTRUCTION OF PLANT.

During the year a large amount of repair and construction work was done at the boat yard in Fountain City. One large quarter boat, 8 barges, and 4 large skiffs were built. Repairs were made to towboat *Alert*, launches *Ada* and *Elsie*, dredge *Vulcan*, 2 dump boats, 7 quarter boats, 14 barges, and 17 skiffs. At such times as the plant was not in use watchmen were employed in caring for same.

CONSTRUCTION OF CABLE HOIST AT BRITTS LANDING, WIS.

Under authority granted by Department indorsement of June 28, 1895, for the purchase of a cable hoist at a cost not to exceed $8,000 for the hoist complete, an agreement was entered into July 11, 1895, with the Trenton Iron Company, of Trenton, N. J., for the delivery of a cable hoist for transporting rock from the quarry to the river at Britts Landing, Wis. The price agreed upon was $4,130.

The work of constructing the towers, fitting up the machinery, and stretching the cables was done by hired labor and use of Government plant, and all material used was purchased in open market under public notice of ten days and sealed proposals. This work was commenced August 18, but owing to delays in the delivery of cables and machinery the hoist was not completed until October 17. The towers are built of pine and oak lumber, framed and bolted together. The crown of the river tower is 68.15 feet above low water of 1864. The outside legs of this tower rest on a crib in the river and the inside legs are placed against the hard bank, giving a space of sufficient width under the tower to permit the handling of barges while they are being loaded. The shore legs of the river tower are protected by a bulkhead running parallel to the shore and used to rest the barges against while loading. The space between the shore and the bulkhead is filled in with rock and brush. The head tower in the quarry is built to a height of 41 feet 4 inches above floor of quarry. The span or distance between the towers is 811 feet. The line of cableway passes over the Chicago, Burlington and Northern Railway Company's track and telegraph line, the cable belng suspended in the air 64 feet above the railroad track. The railroad and telegraph lines are protected from any possible damage, in case the hoisting lines should part, by cross lines of iron rope spanning the framework on either side of the track over the telegraph wires. The main cable is of patent locked wire, 2 inches in diameter and 945 feet 2 inches in length. One end of the cable is anchored to the bottom of the crib under the river tower and the other end is fastened to a dead-man securely set in the ground back of the head tower. The total length of the cable and anchorage chains is 1,045 feet 5 inches. The deflection of the cable between towers is 47 feet.

The equipments are as follows:

One 5-ton cable-way carriage, with patent latch apron and guides for use in connection with duplex fall-rope carriers and fall block.

Ten steel skips made of $\frac{3}{8}$-inch steel, 7 by 7 by 2 feet.

One fall-rope carrier.

One endless rope for holding carriage in position, made of steel wire, 1,646 feet long and five-eighths of an inch in diameter.

One hoisting rope for hoisting drum on engine, made of steel wire, 931 feet long and three-fourths of an inch in diameter.

One $\frac{1}{2}$-inch steel wire rope 876 feet long, used for holding fall-rope carriers in position.

One upright boiler and engine, made by the American Hoist and Derrick Company. The engine is a reversible link motion, with double cylinders, $8\frac{1}{4}$ by 10 inches, geared 5 to 1 to a hoisting drum 40 inches in diameter, having a 34-inch face grooved for a $\frac{3}{4}$-inch line, and governed by a foot brake. The engine and boiler are inside of the head tower in the quarry. The water for the boiler is supplied from a tank adjoining the engine room, filled by pumping the water through a line of pipe extending from the river bank to the quarry.

In connection with the hoist the necessary railroad track was laid in the quarry, and ten small flat cars were constructed for transporting the empty and loaded rock skips between the hoist and loading points.

When the cable hoist was given its test it was found that certain changes would be required in the method of operating it before the Government could accept the hoist. These changes are now being made by the Trenton Iron Company at their expense, and it is expected that the hoist will be completed and put in good working order by the commencement of field operations in 1896.

The total cost of the cable hoist, with railroad track, cars, and loading dock, is $8,581.55, including $4,130 to be paid the Trenton Iron Company.

GENOA TO PRAIRIE DU CHIEN.

Work in this locality, consisting of the construction and repair of brush and rock dams and shore protections, was carried on in continuation of contract with Albert Kirchner, commenced in 1894, under approved project of August 21, 1894, and allotment of $40,000. The prices paid for material in place were as follows: Rock, $1 per cubic yard; brush, 39 cents per cubic yard.

Operations during 1894 were commenced October 15 and carried on until November 9, the close of navigation. The contractor being desirous of continuing operations during the winter, by substituting teams and sleighs for boats and barges in the transportation of material, work was commenced January 8, 1895, in vicinity of Winneshiek Slough, but owing to the difficulty in procuring and delivering material this method was discontinued February 3, 1895. Work was resumed April 1, 1895,

and carried on until the completion of the contract, June 29, 1895, improvements being made below Genoa, at head of Iowa Slough, between De Soto and Lansing, and at head of Capoli Slough. Five closing dams and four pieces of shore protection were constructed, as follows: Closing Dam 1 (sheet 26), across Winneshiek Slough; Closing Dam 2 (sheet 26), across head of chute between Islands 145 and 146; Closing Dam 3, across head of chute between Islands 143 and 144; Closing Dam 4, across head of chute in Island 144, and Closing Dam 2 (sheet 27), commenced in 1894, across Capoli Slough, was completed; 2,024 feet of shore protection on Island 143, just above the head of Island 144; 456 feet of shore protection around head and down west side of Island 144; 1,992 feet of shore protection on Island 145, just above head of Island 146; and 650 feet of shore protection around head and down west side of Island 146. The following dams and shore protections were repaired and strengthened: Closing Dam 1 (sheet 24), east of Island 126; Closing Dam 1 (sheet 25), across head of Iowa Slough; shore protections at head of Island 126, on Minnesota shore opposite Island 126, on Island 127, and at head of Island 128.

All the dams built or repaired are 4 feet above low water of 1864.

Mr. H. C. Brice was the inspector in local charge of the work.

List of works constructed and repaired and of materials used during season of 1895, under contract with Albert Kirchner, between Genoa and Prairie du Chien.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
Sheet 24:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Closing dam 1 repaired	.....	.....	1,350.6	1,214.7
Shore protection, Island 126, repaired	.....	.....	67.4	.....
Shore protection, Minnesota shore, opposite Island 126, repaired	.....	.....	662.5	300
Shore protection, Island 127, repaired	.....	.....	706.6	.....
Shore protection, Island 128, repaired	.....	.....	138.4	.....
Sheet 25: Closing dam 1 repaired	.....	.....	2,095	1,578.3
Sheet 26:				
Closing dam 1	475	4	4,140.5	4,432.6
Closing dam 2	211	4	439.6	1,064.6
Closing dam 3	130	4	214.1	355.8
Closing dam 4	181	4	316.7	221.7
Shore protection, Island 143	2,024	.....	2,861.2	2,914.5
Shore protection, Island 144	146	.....	846.1	553.4
Shore protection, Island 145	1,992	.....	4,381.9	2,626.9
Shore protection, Island 146	650	.....	1,054.3	650.8
Sheet 27: Closing dam 2 completed	211	.....	771.9	839.7
Total	6,330	.....	20,046.8	16,753

Financial statement for work between Genoa and Prairie du Chien, performed under contract with Albert Kirchner in 1894 and 1895 (entire contract).

Amount paid contractor		$31,926.35
Cost of local inspection, etc		1,633.62
Add quota of general superintendence and office expenses		835.43
Total		34,395.40
Material put in works, 1894 and 1895:		
Rock	cubic yards	23,851.2
Brush	do	20,705.5
Total	do	44,556.7
Average cost per cubic yard in place		$0.772

Under project approved April 17, 1895, and allotment of $40,000, a contract dated June 16, 1895, was entered into with Albert Kirchner for the construction of dams and shore protections of rock and brush between Genoa and Prairie du Chien at $1 per cubic yard for rock and 14 cents per cubic yard for brush in place. No work was done during 1895.

Respectfully submitted.

W. A. THOMPSON, *Superintendent.*

Lieut. Col. W. R. KING,
Corps of Engineers, U. S. A.

REPORT OF MR. J. C. M'ELHERNE, SUPERINTENDENT.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., January 22, 1896.

COLONEL: I have the honor to submit the following report of operations for improvement of the Mississippi River, in the division in my local charge, for the calendar year ending December 31, 1895:

GLENHAVEN TO DUBUQUE.

Under project approved August 21, 1894, and allotment of $40,000, a contract dated October 18, 1894, was entered into with Albert Kirchner for the construction of brush and rock dams and shore protections at 39 cents per cubic yard for brush and $1 per cubic yard for rock in place.

The work accomplished, all of which was in the vicinity of Spechts Ferry, was commenced July 3, 1895, and finished September 28, at which latter date the contract was completed. A series of dams was built extending from the Illinois shore opposite Spechts Ferry, the chute of Island 210 was closed, and the head of the island protected.

These dams close the former troublesome crossing over the long shoal bar, and have caused a good deep channel down along the Iowa shore.

Mr. C. A. Stoddard was the local inspector and performed his duties in a very satisfactory manner.

List of works constructed and materials used during the season of 1895, under contract with Albert Kirchner, between Glenhaven and Dubuque.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
Sheet 35:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Closing dam	810	5	5,906.6	7,832.8
Wing dam 3	508	5	1,546.5	1,501.1
Wing dam 4	425	4.5	1,432.8	1,792.4
Wing dam 5	1,100	3.5	5,306.5	8,141.2
Wing dam 6	1,300	3	4,366.8	6,775.9
Wing dam 7	1,350	3	5,448	7,311.5
Shore protection on Island 210	600	.....	1,237.4	1,124.9
Total	6,093	.....	25,244.6	34,479.8

Financial statement for work between Glenhaven and Dubuque, performed under contract with Albert Kirchner during season of 1895.

Amount paid contractor	$38,691.72
Cost of local inspection, etc	1,127.65
Add quota of general superintendence and office expenses	1,007.43
Add for use and deterioration of plant	62.16
Total	40,888.96
Material put in works:	
Rock, cubic yards	25,244.6
Brush, do	34,479.8
Total, do	59,724.4
Average cost per cubic yard in place	$0.685

DUBUQUE TO CLINTON.

Work in this section was carried on under two contracts.

Contract of 1894.—Under project approved August 21, 1894, and allotment of $40,000, a contract dated October 18, 1894, was entered into with Jacob Richtman for the construction of brush and rock dams and shore protections at 20 cents per cubic yard for brush and $1.30 per cubic yard for rock in place.

Only a part of this contract having been worked out at close of 1894, operations

were continued in the vicinity of Fulton from January 1, 1895, to March 3, by furnishing the material on wagons over the frozen river. At this period the ice broke up, and to await an open river and get the fleet in readiness an intermission was taken until April 1, on which date work was resumed and carried on until the completion of the contract, on May 4.

The work accomplished was the completion of shore protection on left bank of river, above foot of Upper Cattail Slough, to a point 1,300 feet above its mouth; the construction of Closing Dam 5 across narrow chute at upper end of this protection; of Closing Dam 6 from foot of Island 287 to first towhead; of Closing Dam 7 from first towhead below Island 287 to second towhead, and of shore protection 43 feet wide from Dam 7 to foot of willows on bar.

At Elk River Slough were built: Closing Dam 8, across very deep chute, between Islands 280 and 281; Closing Dam 9, between Islands 279 and 280, and shore protection, 43 feet wide, from Dam 8 around head of Island 281. The long shoal crossing abreast of Island 287 was thereby very noticeably benefited, and the closing of the two chutes entering Elk River Slough had the effect of greatly widening and deepening the channel along east side of Island 281.

The channel shore of this island throughout its entire length, together with the main right shore immediately below, is cutting away, and should receive attention at the earliest opportunity.

Mr. C. A. Stoddard, as inspector, gave satisfaction in the discharge of his duties.

List of works constructed and materials used during season of 1895, under contract with Jacob Richtman, between Dubuque and Clinton.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
Sheet 43:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Closing dam 5	54	4	190.4	194.2
Closing dam 6	250	5	842.5	660.5
Closing dam 7	400	6	1,080.6	692.3
Closing dam 8	500	5	4,844.6	5,567.9
Closing dam 9	180	5	1,467.3	1,266.6
Shore protection at Cattail Slough	600	.....	1,983.9	194.2
Shore protection at foot of Island 287	200	.....	370.1	169.6
Shore protection, head of Island 281	624	.....	1,828.9	845.4
Total	.....	.....	12,608.3	9,590.7

Financial statement for work between Dubuque and Clinton performed under contract with Jacob Richtman during seasons of 1894 and 1895 (entire contract).

Amount paid contractor		$31,143.61
Cost of local inspection, etc		1,320.67
Add quota of general superintendence and office expenses		790.39
Add for use and deterioration of plant		48.84
Total		33,294.51
Material put in works:		
Rock	cubic yards	21,030.5
Brush	do	18,974.8
Total	do	40,005.3
Average cost per cubic yard in place		$0.832

Contract of 1895.—Under project approved April 17, 1895, and allotment of $40,000, a contract dated June 16, 1895, was entered into with Albert Kirchner for the construction of brush and rock dams and shore protections, at 14 cents per cubic yard for brush and $1 per cubic yard for rock in place.

Work was commenced October 1, 1895, in the vicinity of Deadmans Bar, where a crossing very troublesome in low stages existed for many years. To close off Raft Channel and thereby force an increased volume of water down over this bar Dam 1 was built from head of Island 235 over to the Illinois shore. A shore protection 60 feet wide was also put in from Dam 1 entirely around head of Island 235 for a

distance of 700 feet. The effect of the work done was to deepen and greatly improve the condition of the above-mentioned crossing.

Operations were suspended on November 6, to be resumed elsewhere early in 1896.

The inspector, Mr. C. A. Stoddard, performed the duties pertaining to the work very efficiently.

List of works constructed and materials used during season of 1895, under contract with Albert Kirchner, between Dubuque and Clinton.

Designation.	Dimensions.		Material.	
	Length.	Heigth above low water, 1864.	Rock.	Brush.
Sheet 38:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Closing dam 1	1,150	4	7,115.9	7,566.4
Shore protection, head of Island 235	700	.....	2,080.5	1,884.8
Total	.....	.....	9,196.4	9,451.2

Financial statement for work between Dubuque and Clinton performed under contract with Albert Kirchner during season of 1895.

Amount paid contractor		$9,467.61
Add retained percentage		1,051.95
Add cost of local inspection, etc		707.35
Add quota of general superintendence and office expenses		284.04
Total		11,510.95
Material put in works:		
Rock	cubic yards..	9,196.4
Brush	do.....	9,451.2
Total	do.....	18,647.6
Average cost per cubic yard in place		$0.617

DREDGING IN THE VICINITY OF PRINCETON.

From July 9 to 16, 1895, dredge *Ajax* effected the removal of three dangerous rock ledges blasted in 1894 from mid-channel in the long crossing directly opposite the town. The combined area of these patches was 60 by 215 feet and the rock varied in height above grade from 0.5 to 1.5 feet. Launch *Louise* tended the dredge, and with the necessary number of barges handled the material, which was all towed down river and utilized to good advantage in the dams on the Rock Island Rapids.

Six hundred cubic yards of loose and broken rock were dredged and removed, at a cost of $558, including superintendence and plant charge—an average of 93 cents per cubic yard.

IMPROVING ROCK ISLAND RAPIDS.

The fleet having been thoroughly repaired, was on April 8, 1895, set at work at Duck Creek and upper chains.

Dams.—In the vicinity of Duck Creek Chain Dams 9, 10, and 11 were raised on the downstream side, where the aprons had sustained injury, and in addition the latter dam was slightly lengthened. Dam 13 was built, partly of brush, across the chute on upper side of the delta at mouth of Duck Creek, to divert the flood water of that stream through the lower outlet and away from the channel. For the purpose of securing a still greater depth of water and counteracting the strong cross currents in this locality, Trailing Dams 9½ and 11½ were constructed, reaching from head to foot of the chain, on opposite sides of the channel and on lines parallel with it, the former connecting the outer ends of Wing Dams 9 and 10 on the north side, and the latter extending down river from the outer end of Dam 11, on the south side of the channel. A heavy brush mat covering was given to Dam 9½, to prepare it the better to withstand ordinary wear. The effect of these dams was to straighten the current and at low water to increase the depth 2 feet at head of the chain without materially increasing the depth at the lower end, owing to the water at that point being immediately drawn off into the upper end of a very deep long pool. To raise the water on the lower part of this chain the construction of two wing dams, 16 and 17, from Iowa shore, was commenced, at distances of 6,000 and 2,100 feet respectively, below the foot of the chain.

Dam 16, laid roughly out over the reef and well above the water surface to the edge of the channel, slackened the current considerably well up to the trailing dams. In Dam 17 the rock so far used was deposited only across the very deep water or steamboat channel 400 feet in width, a section to be built submerged at an elevation of 6 feet below low water. This material, distributed along unevenly on the line of the dam to serve as a foundation, was carried up to within 4 feet of the desired height and caused an additional gain of 0.12 of a foot of water at the foot of the chain. Dam 7 was extended across a little slough which had begun to increase in size at the lower end of Campbells Island. At the head of Campbells Chain, Dam 3, at north side of river, and Dam 4, from head of Campbells Island, were both lengthened, widened, and raised in preparation for paving. Dam 15 was commenced and built up to low water elevation across the deep, narrow, swift chute setting off from the channel above the dangerous shoulder on the north side of Sycamore Chain.

Paving the dams.—In the upper and lower sides of Dams 3 and 14 deep ditches were sunk parallel with the lines of the dams and well down below low water. Sloping walls of very heavy stone for the foundations of the paving were built in these trenches, and two rows 3 feet apart of the same material were set in on edge as center curbing for strengthening purposes. All the intermediate spaces were then filled in with large rock neatly placed and rounded off into a flat top toward the center. This arrangement made a strong pavement 3.5 feet above low water and 12 feet in width, except on the outer end of Dam 3 for a distance of 155 feet, the full completion of which a sudden rise in the river unfortunately prevented.

Rock excavation.—Two steam drill boats with double crews were busily engaged throughout the season. From April 8 to September 11, 1895, Drill Boat 6 operated on long, high shoulder and two smaller ones on north side of Sycamore Chain and on two prominent points on the opposite side of the channel. The reefs, ranging in height from 1 to 3.5 feet above grade and being for the most part exceedingly shoal, covered an area 68 by 1,150 feet and were worked over with much difficulty. September 12 to 27 an area covering 200 by 500 feet at lower end of Duck Creek Chain, was swept and cleared of loose rock and many bowlders. September 28 to October 30 high points and small patches, varying from 0.5 to 2 feet above grade and covering an area 70 by 800 feet at north side of Winnebago Chain were searched and reblasted, and from October 31 to November 2 two small patches, 1 to 2 feet above grade, with an area 68 by 80 feet at south edge of channel opposite upper part of Moline Pool, were blasted.

Drill Boat 103 worked from April 9 to May 14 on the north half of the new cut through Upper Chain, blasted the remaining patches averaging from 0.5 to 1 foot above grade, and also dragged the broken rock into deep water. In this way an area 75 by 530 feet was successfully worked over. The time from May 15 to October 24 was very satisfactorily put in on large, high, abrupt shoulder at upper side of Lower Chain. The section worked over varied from 0.5 to 3.5 feet above grade and covered an area of 125 by 500 feet. During the prevalence of low water the highest portions of the ledge were temporarily abandoned, but were blasted when the river rose to a suitable stage.

Dredging.—Dredge *Ajax*, with double crew, began on April 14, 1895, removing the heavy bank of rock blasted in 1894 at long, high shoulder at north side of Lower Chain. Having finished this on May 8, the time until June 29 was employed on the disrupted patches in pool above Moline Chain and in removing the old dike above Moline Pool. All rock was removed from the former locality but not entirely so from the latter. On July 16 the dredge returned from Princeton and by August 29 succeeded in taking out two small patches and the long, deep shoulder of broken rock at north side of Sycamore Chain. Between August 30 and October 5 the rock blasted in 1894 at the north side of Winnebago Chain was dredged. The remainder of the season until November 19 was utilized very satisfactorily in removing the broken rock from the high, abrupt shoulder at upper side of Lower Chain.

Removing loose rock and bowlders.—Barge 27, in addition to derrick, grapplings, etc., already on hand, was furnished with four new spuds and the necessary gearing, and rendered very valuable service in removing small ledges, loose rock, and bowlders, especially during very low water and at such times as a drill boat or dredge could not be spared for the purpose.

The large areas dredged over in pool above Moline Chain and in the vicinity of Sycamore Chain were carefully swept and cleared of bowlders and loose rock, together with a few solid high patches and projecting reef points, which were first shattered by blasting. Such débris as was shoved up on the reefs outside of the channel by the dredge was likewise gathered up. Sweeping was also done at lower end of Duck Creek Chain, from which a few dangerous bowlders were taken, and a considerable amount of widely scattered material of large and small dimensions was removed from the foundation of the old dike above Moline Pool, but owing to falling river the latter locality was abandoned before the dike was entirely removed.

Operations were closed for the season on November 19, and the fleet was then laid up in Moline Pool in charge of a watchman.

Details of operations.

Launch *Louise*.	
Hours working	2,249
Miles run, light	2,539
Miles run, towing	4,323
Miles run, total	6,862
Towboat *Mac:*	
Hours working	2,221
Miles run, light	2,094
Miles run, towing	6,135
Miles run, total	8,229
Drill Boat No. 6:	
Hours working	2,856
Hours lost owing to rafts	68
Hours lost owing to accidents	4
Hours lost owing to storms	17
Holes drilled	4,955
Holes blasted	4,784
Linear feet of holes drilled	15,577
Range poles set in rock bottom	171
Solid cubic yards of rock blasted	4,100
Cubic yards of loose rock and bowlders removed	75
Pounds of dynamite used	8,981
Drill Boat 103:	
Hours working	2,598
Hours lost owing to rafts	30
Hours lost owing to accidents	51
Hours lost owing to storms	1
Holes drilled	3,605
Holes blasted	3,519
Linear feet of holes drilled	14,068
Range poles set in rock bottom	86
Ring bolts set	2
Solid cubic yards of rock blasted	3,533
Cubic yards of loose rock raked into deep water	307
Pounds of dynamite used	11,940
Dredge *Ajax:*	
Hours working	2,544
Hours lost owing to rafts	44
Hours lost owing to accidents	231
Solid yards of rock dredged and removed	6,158
Cubic yards of loose rock and bowlders dredged and removed	15,202
Derrick Barge 27:	
Hours working	490
Cubic yards of bowlders and ledges blasted	88
Cubic yards of bowlders and loose rock removed	743
Pounds of dynamite used	24

Summary of total amounts of material.

Solid cubic yards of rock blasted	7,721
Solid cubic yards of rock dredged and removed	6,158
Cubic yards of loose rock and bowlders dredged and removed	16,327

Cost of rock excavation, including charge for use and deterioration of plant.

Locality.	Rock excavated (solid cubic yards).	Total cost.	Average cost per solid cubic yard.
Foot of Upper Chain, removed	474.9	.....	.....
Sycamore Chain, removed	3,500	.....	.....
Winnebago Chain, removed	20	.....	.....
Pool above Moline Chain, removed	16	.....	.....
Upper shoulder of Lower Chain, removed	2,146.8	.....	.....
Total	6,157.7	$23,091.38	$3.75
Sycamore Chain, blasted only	188.1	.....	.....
Winnebago Chain, blasted only	388.1	.....	.....
Pool above Moline Chain, blasted only	25.8	.....	.....
Upper shoulder of Lower Chain, blasted only	960.9	.....	.....
Total	1,562.9	4,407.38	2.82
Grand total	7,720.6	27,498.76	.....

List of dams and of material used in their construction and repair during season of 1895.

Designation.	Filling.			Paving.		
	Total length.	Riprap.	Brush.	Slope wall.	Riprap.	Total.
Sheet 47:						
Wing dam 3, widened, raised, extended 100 feet (paved)	*Feet.* 100	*Cu. yds.* 9,311.8	*Cu. yds.*	*Cu. yds.* 661.3	*Cu. yds.* 1,300	*Cu. yds.* 1,961.3
Closing dam 7, extended 100 feet	100	591.8	91.3	.....	.....	.....
Wing dam 9, widened	.....	490	.....	.....	.....	.....
Trailing dam 9½	1,250	4,625.7	1,090	.....	.....	.....
Wing dam 10, widened	.....	850	.....	.....	.....	.....
Wing dam 11, widened and extended 60 feet	60	1,560	.....	.....	.....	.....
Trailing dam 11½	2,100	12,155.7	.....	.....	.....	.....
Closing dam 13	80	522.8	300	.....	.....	.....
Wing dam 14, extended 500 feet and paved	500	3,261.6	.....	191.8	550	741.8
Colsing dam 15, commenced	.....	334	.....	.....	.....	.....
Wing dam 16, commenced	.....	3,027.9	.....	.....	.....	.....
Wing dam 17, commenced	.....	4,140	.....	.....	.....	.....
Total	.....	40,871.3	1,481.3	853.1	1,850	2,703.1

Cost of dams, including charge for use and deterioration of plant.

Material.	Cubic yards.	Cost.	Cost per cubic yard.
Riprap stone in place	40,871.3	$40,163.15	$0.983
Paving stone in place	2,703.1	8,785.08	3.25
Total	43,574.4	48,948.23	.....

Average cost per cubic yard in place $1.123

Financial statement for improvement of Rock Island Rapids for season of 1895.

Amount expended in field	$66,677.61
Add quota of general superintendence and office expenses	1,686.94
Add for use and deterioration of plant	8,082.44
Total	76,446.99

Distributed as follows:

1. Rock excavated and removed	23,091.38
2. Rock broken up but not removed	4,407.38
3. Dams 3, 7, 9, 9½, 10, 11, 11½, 13, 14, 15, 16, 17	48,948.23
Total	76,446.99

BUOYS ON ROCK ISLAND RAPIDS.

The buoys, having been thoroughly repaired and painted, were reset, and the range posts readjusted and renewed where necessary between April 1 and 14, 1895. During the season Nos. 1, 10, and 18 were reset three times and Nos. 12 and 21¼ twice. No. 25, blasted out, has not yet been relocated. Nos. 17½ and 24, being near guide piers, were discontinued as unnecessary. There are now 27 buoys in the system. From November 1 to 6 the range posts were again carefully examined and replaced where disturbed and the buoys taken up and stored for the winter.

Cost of buoyage for the season was $326.61.

SURVEY.

A survey of the river in vicinity of Rock Island was made between September 3 and 5, 1895, for the purpose of ascertaining changes in the condition of the extensive sand bar in that locality. The examination extended from the Chicago, Rock Island and Pacific Railroad Bridge down to a point some distance below the steamboat landing in front of the city.

Soundings located instrumentally were taken from shore out over the bar to deep water on lines 50 feet apart. The notes were immediately afterwards platted in the office.

There were 1.7 miles of transit lines run and 1,466 soundings taken.

Cost in field of above survey work was $27.

Very respectfully submitted.

J. C. McELHERNE,
United States Superintendent.

Lieut. Col. W. R. KING,
Corps of Engineers, U. S. A.

REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., January 15, 1896.

COLONEL: I have the honor to submit the following report of operations for improvement of the Mississippi River in the division in my local charge for the calendar year ending December 31, 1895.

MUSCATINE TO NEW BOSTON.

Under project approved March 9, 1895, and allotment of $45,000 from appropriation of August 18, 1894, a contract, dated May 3, 1895, was entered into with Patterson Bros. for the construction of brush and rock dams and shore protections, at $1.12 per cubic yard for rock and 13 cents per cubic yard for brush, in place. Operations were begun June 27, 1895, and concluded November 13, on completion of the contract.

Illinois Slough.—A bad crossing, with less than 3 feet at low water, caused great trouble in 1893 and 1894 and in several former years. A wing dam and two closing dams were built, and an increased depth was immediately obtained. Considerable additional work will be needed in this locality to straighten the channel.

Port Louisa.—A piece of high caving bank, 3,279 feet in length, was thoroughly protected.

Dodges.—Steamboats meeting with obstructions at this locality, which is at the upper end of Buffalo, one closing and two wing dams were built to concentrate the channel at the bad crossing. It was intended to build several more dams, but the effect of those built proving very useful, operations were transferred to Fairport.

Fairport.—At this place a long crossing offered two points of obstruction, which were annoying to navigators. Toward the end of the season four wing dams were built, two from the Illinois and two from the Iowa side. The effect of these dams has not as yet been observed.

Mr. E. A. Sisson, the local inspector, gave excellent satisfaction.

List of works constructed and repaired, and of materials used, during season of 1895, under contract with Patterson Bros., between Muscatine and New Boston.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
Sheet 49:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Closing dam 1, repaired	.....	.....	216.7	204.0
Closing dam 3	410	4	2,757.1	3,582.7
Wing dam 4	883	4	3,500.6	3,725.6
Wing dam 5, not completed	800	.....	1,351.4	1,186.6
Sheet 50:				
Wing dam 1	659	4	1,398.5	1,435.3
Wing dam 2	660	4	3,017.5	2,462.7
Wing dam 3	583	4	2,121.6	1,945.0
Wing dam 4	993	4	2,444.5	2,594.4
Sheet 53:				
Closing dam 1	1,012	4.5	3,709.9	5,267.2
Closing dam 2	1,040	4	3,192.2	4,168.2
Wing dam 3	760	4	1,879.9	4,321.8
Shore protection, Island 348	488	.....	634.5	714.2
Shore protection at Port Louisa	3,279	.....	4,963.7	4,499.0
Total	.....	.....	31,188.1	36,106.7

Financial statement for work between Muscatine and New Boston, performed under contract with Patterson Bros. during 1895.

Amount paid contractor		$39,624.54
Cost of local inspection, etc		1,029.20
Add quota of general superintendence and office expenses		1,028.54
Add for use and deterioration of plant		53.65
Total		41,735.93
Material put in work:		
Rock	cubic yards	31,188.1
Brush	do	36,106.7
Total		67,294.8
Average cost per cubic yard in place		$0.621

FLINT CREEK TO IOWA RIVER LEVEE.

The sundry civil act of March 2, 1895, in making appropriation for improvement of Mississippi River from the mouth of the Missouri River to Minneapolis, provides—

"That * * * eighty-five thousand dollars thereof shall be expended to commence the work, under the direction of the Secretary of War, from the mouth of Flint Creek, in Des Moines County, State of Iowa, and running along the west bank of the river to the mouth of the Iowa River, with a view to improving the navigation by preventing the water from overflowing the natural and artificial banks along that part of the river, and deepening the channel, in accordance with the survey reported on January third, eighteen hundred and ninety-five, and the accompanying estimate."

Lieutenant-Colonel Mackenzie, in his project dated April 11, 1895, approved by the Secretary of War April 18, 1895, quoting from his report, says:

"The questions of outlets and interior drainage have not been considered. An earthen bank is estimated for, with a slope of 3 to 1 on the river side and 2 to 1 on the inside, with 4 feet width of crown, to reenforce and raise the natural bank where necessary, and following the transit lines as above described. The grade of the top of the bank is placed at 3 feet above high water of 1888, which will probably be of sufficient elevation to restrain any flood that is likely to occur. The average height of artificial bank will be about 8½ feet and its length 42 miles."

The estimate calls for 1,855,193 cubic yards earthwork, at 15 cents per yard, and, adding 10 per cent for engineering and contingencies, amounts to $305,000.

Colonel Mackenzie's project further says:

"With the money available ($85,000) it is proposed to construct a levee from Flint Creek to the Iowa River of the same slopes and width of crown as given above, its grade to be as high as funds will permit. It is thought best to build a complete levee, which will be of sufficient height to resist all but very high floods, and afterwards enlarge it, as appropriations may be made. * * * I would propose to perform the work by formal contract." * * *

While the surveys for permanent location of levee were in progress efforts were made to obtain right of way free of expense to the Government. In this we were successful for about 22 continuous miles of the levee, commencing at the Iowa River, but at the lower or Flint Creek end a great many of the owners refused to donate right of way and demanded exorbitant prices for the same, notwithstanding the fact that the levee will be a great benefit to them. Deeming it unwise to pay the prices asked for right of way, or to await the issue of condemnation proceedings, it was decided to build the levee to its full height, commencing at the Iowa River end and running down as far as funds will permit, the right of way for this portion having already been secured. A modified project was presented by Lieutenant Keller with this object in view, which project was approved June 28, 1895.

Early in May, 1895, a party was put in the field to make a permanent location of the levee. A transit line was run from a point up the Iowa River above high water down the south bank of this river to its mouth, and thence along the west bank of the Mississippi River to Flint Creek, and up the creek to high ground. Careful levels and topography were taken, and the maps and profiles were plotted.

After the final location had been made the entire line was cross sectioned, slope and mile-section stakes were set, and computations of quantities made, and later borrow pits and right of way were staked out, putting matters in proper shape for contract work.

On August 5 bids were received to the number of 21, the prices per cubic yard of earthwork ranging from 8.18 cents to 28.50 cents. The contract was awarded to M. H. King, of Des Moines, Iowa, at 8.18 cents per cubic yard, a very low price.

The contractor delayed commencement of work until October 4, losing a very favorable month, and since that time his progress has not been satisfactory. The first 4 miles have been completed, the fifth is nearly finished, and a large amount of work has been performed on mile sections 6 to 10, inclusive. The amount of earthwork completed to December 31, 1895, was 97,171 cubic yards.

Two lines of 36-inch iron pipe fitted with valves were laid in Iowa Slough for drainage purposes.

All of the survey and construction work, including the preliminary survey made in 1894, has been in local charge of Mr. E. E. Barrett, inspector, who has performed his duties conscientiously and well.

Statement of expenditure.

Surveys for final location, etc	$5,083.37
Right of way (recording deeds)	35.25
Drainage (iron pipe and laying same)	739.98
Inspection, office expenses, etc	2,619.59
Earthwork	*7,948.59
Total to December 31, 1895	16,426.78

Very respectfully, your obedient servant,

C. W. DURHAM, *Assistant Engineer.*

Lieut. Col. W. R. KING,
Corps of Engineers, U. S. A.

REPORT OF MR. M. MEIGS, UNITED STATES CIVIL ENGINEER.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, February 1, 1896.

COLONEL: I have the honor to submit the following report of work performed under my direction between Keithsburg and Quincy for the calendar year ending December 31, 1895:

KEITHSBURG TO NASHVILLE.

Dams and shore protections.—The work of building brush and rock dams, and also the operations of United States plant with towboat *Vixen*, were under the local charge of Mr. John R. Carpenter, overseer, from whose reports extracts are given below. The water during the season past was at times down to extreme low water, somewhat interfering with the construction of dams, and often in shoal places requiring a second handling of material. The work at Keithsburg, however, was done during a slight rise in the river, with but little trouble, and notwithstanding the long tow of the rock from Burlington was as cheap as any work accomplished during the season.

Three bad places in the channel presented themselves during low water, namely, Benton Island, Twin Island, and Lead Island crossings. At all these places considerable work was done, and while the channel at the close of the season had not settled down to a stable condition, owing to the large amount of sand put in motion by the construction of the dams, it was in each case much improved and promises to offer no obstructions next year.

"The work was carried on by hired labor and use of Government plant, launch *Lucia*, launch *Stella*, steamer *Climax* (chartered), and steamer *Vixen* being employed at different intervals during the season towing the material to the required points, and dredge *Phœnix* on two occasions removing snags preparatory to protecting banks.

"Operations were begun on April 4 in the locality of Skunk River. The head of Twin Island was protected, the protection being carried down the east side of the island a distance of 390 feet. The crossing above this island having become very difficult to navigate, owing to the reef above having approached very close to the head of the island, it was found necessary to close off the steamboat channel west of the island and throw all the water down the east side. Accordingly, a closing dam (No. 3, sheet 59) was built from the United States light at the mouth of Skunk River to a point 512 feet below the head of Twin Island. After the completion of Closing Dam No. 3, 2,685 feet of shore protection was built on Burlington Island, between the two pieces of old shore protection previously constructed, and 1,710 feet from a point 733 feet above the United States light on Burlington Island, opposite the head of Twin Island, to a point 977 feet below the light. Closing Dam 10 (sheet 60) was built in Peels Slough from Peels Island (No. 381) to the sand bar opposite the foot of Burlington, to prevent the water from drawing down the slough. After a few slight

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*Includes December estimate paid in January, 1896, and retained percentage.

repairs to the shore protection in Sauerwein Bend and on Thompson Island, the fleet was towed to Keithsburg, Ill. From June 1 to August 12 work was continued in this vicinity and that of Benton Island. Dam 14 (sheet 55) was rebuilt and lengthened 500 feet. Dam 15 was repaired and extended 125 feet. Closing Dam 18 was repaired and raised. The shore of Huron Island was protected from the head of the island to Dam 18. A closing dam (No. 3, sheet 56) was built across the slough from Island 361 to Island 362, and a wing dam (No. 2) was built out from the foot of Island 363. Dam 1, in Benton Slough, was repaired and raised, and 2,994 feet of bank on main shore above Benton Island was protected.

"The fleet was then towed to Twin Island, and the remainder of the season was spent in this vicinity and in vicinity of Pontoosuc. Dam 4 (sheet 59) was built across the small slough above Twin Island to prevent the back water from Dam 3 running into Skunk River. A wing dam (No. 5) was built out from the east side of Twin Island, to cut out a number of sand bars and reefs which had formed in this portion of the river, making navigation very uncertain. After completion of this dam work was commenced making the necessary repairs to Dams 14, 17, and 19 (sheet 60), to improve the crossing at Lead Island, which was very bad. These dams were repaired, lengthened, and raised, and a new wing dam (No. 20) was built from sand bar above Dam 17, which put the crossing in very good shape. Operations were then resumed at Twin Island, the channel having become very crooked at that point. Three wing dams were built from the Iowa side, the upper one about 3,000 feet below Skunk River. Two thousand two hundred and sixty-three feet of shore protection was built on foot of Thompson Island, on completion of which work was abandoned for the season (November 13) and the fleet laid up for the winter."

List of works constructed and repaired and of material used during season of 1895 between Keithsburg and Nashville.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
Sheet 55:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Dam 14, repaired and extended	500	3	2,441.5	6,383.2
Dam 15, repaired and extended	125	3	1,115.7	2,276.5
Dam 18, raised to 5 feet	.....	5	495.4	466
Shore protection, Island 358	1,100	8	977.7	1,006.9
Sheet 56:				
Dam 1, repaired and raised	.....	5	381.8	729.9
Dam 2	1,400	4	2,120.3	6,877.8
Dam 3	900	5	1,596.9	4,600.9
Shore protection, Benton Island	2,994	7	2,251.4	2,522
Sheet 59:				
Dam 3	913	5	6,133.9	6,182
Dam 4	239	3	205.7	1,029.4
Dam 5	764	1	1,629.4	2,287.6
Dam 6	900	2 to 4	2,335	3,410.2
Dam 7	800	1 to 4	903.4	3,070.6
Dam 8	525	1 to 4	686	1,728.3
Shore protection, Island 381	390	8	547	442.6
Shore protection, Island 379	4,395	6	3,880.7	3,637.1
Shore protection, Sauerweins Bend, repaired	.....	.....	363.3	.....
Shore protection, Island 379, repaired	.....	.....	386.7	.....
Sheet 60:				
Dam 10	1,200	0	1,207.3	2,924.7
Dam 14, extended	500	3 to 5	3,244.2	5,511.4
Dam 17, repaired and extended	150	5	2,663.9	3,971.5
Dam 19, repaired	.....	3	2,365.4	3,492
Dam 20	800	1	1,865.7	2,933.7
Shore protection, Island 384	2,263	6	1,733.8	2,490.7
Shore protection, Island 384, repaired	.....	.....	97	.....
Total	.....	.....	41,629.1	67,975

Financial statement for building dams and shore protections between Keithsburg and Nashville during season of 1895.

Amount expended in field during calendar year 1895 (from distribution sheets)	$58,494.03
Add quota for general superintendence and office expenses	1,479.90
Add for use and deterioration of plant	5,562.58
Total	65,536.51

Material put in work:		
Rock	cubic yards..	41,629.1
Brush	do....	67,975
Total	do....	109,604.1
Average cost per cubic yard:		
On barges		$0.349
For towing and putting in place		.184
For general superintendence and office expenses		.014
For use and deterioration of plant		.051
Average cost per cubic yard in place		.598

Dredging rock.—The operations of dredge *Phœnix* and tender were in charge of Mr. Byron Layton, overseer, from whose reports extracts follow below. The season offered too low water for the best prosecution of work, the *Phœnix* doing her best work in 9 to 10 feet of water instead of 5 to 6; but on the whole the results were satisfactory. The channel attained at Keithsburg is 450 to 500 feet wide, and sufficient for all present needs, with a grade of 5 feet at extreme low water.

"(*a*) *Removing rock at head of Des Moines Rapids.*—This work was begun April 26, 1895, and consisted in removing the rock in vicinity of Pier 4, drilled and blasted in the spring of 1894, part of which was removed the same fall. The work was finished May 22, and with the rock dredged a new pier (No. 5) was constructed, 50 feet inside and 100 feet above the lower red light. Small repairs were also made to piers 3 and 4. This work secured an almost straight channel from Pier 6 to Pier 3, with 4½ to 5 feet at low water.

Distribution of broken rock removed from channel.

Put in Pier 3, repaired	cubic yards..	92.4
Put in Pier 4, repaired	do....	62.5
Put in Pier 5, new	do....	1,416.6
Total	do....	1,571.5

"(*b*) *Removing rock and bowlders from channel in vicinity of Keithsburg.*—On May 27, 1895, the dredge began removing rock and bowlders from channel in vicinity of Keithsburg, widening the channel made here in the fall of 1895 to 100 feet. This work was finished June 20, making a permanent and safe channel outside of Dam 13 450 feet wide with 5 feet at low water."

Financial statement for removing rock between Keithsburg and Nashville during season of 1895.

Amount expended in field during calendar year 1895 (from distribution sheets)		$2,604.79
Add quota of general superintendence and office expenses		65.90
Add for use and deterioration of plant		686.54
Total		3,357.23
Rock removed and in part placed in piers	cubic yards..	3,910.1
Average cost per cubic yard in place		$0.858

KEOKUK TO QUINCY.

(*a*) *Building dams and shore protections* (*contract*).—This work was performed by contractor Jacob Richtman, under inspector E. A. Sisson, the plant of Patterson Bros. being used, consisting of steamer *Colonel Patterson* and barges. The work was a continuation of a contract entered into in 1894. Operations were resumed March 25, 1895, and were closed June 20, 1895, on completion of the contract.

The condition of the bar at Upper Bludsoe was much improved, and a good channel was maintained at this crossing the whole season. The following extracts are from Mr. Sisson's report:

"Closing Dam 1 (sheet 66) was strengthened. Wing Dam 6 (sheet 63), built in 1894 to a length of 1,492 feet, was extended 260 feet, making its present length 1,752 feet. Shore protection for a length of 4,746 feet was built on the Illinois shore below Upper Bludsoe Crossing. Its height above low water is about 5 feet, and its average width 33 feet. Wing Dam 8 was built to a height of 5 feet above low water. Shore protection for a length of 1,221 feet was built on the small willow island at the lower right-hand side of Island 410. Its average width, except for a space of 131 feet,

where it consists simply of a mat 17 feet wide, is 40 feet. Closing Dam 4 (sheet 65) was built to a height of 5 feet above low water and to a length of 333 feet. Shore protection for a length of 1,180 feet was built on Fox Island. Its height above low water is about 9 feet, with an average width of 40 feet."

List of works constructed and repaired, and of materials used, during season of 1895, between Keokuk and Quincy, under contract of 1894.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
Sheet 63:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Dam 6, extended	260	5	870.6	1,832
Dam 8	713	5	2,645.7	7,091.3
Shore protection, island 407	1,180	9	1,367.7	1,480.3
Sheet 64: Shore protection, Illinois shore, at Bludsoes Crossing	4,746	5	4,291.3	6,034.2
Sheet 65:				
Dam 4	333	5	1,958.3	2,548.1
Shore protection on sand bar below island 410	1,221	9	1,308	1,832.4
Sheet 66: Dam 1, repaired	.....	.....	283.1	.....
Total	.....	.....	12,724.7	20,818.3

Financial statement for work between Keokuk and Quincy, performed under contract with Jacob Richtman, during seasons of 1894 and 1895 (entire contract).

Amount paid to contractor		$35,974.83
Add cost of local inspection, etc		1,145.36
Add quota of general superintendence and office expenses		903.24
Add plant charges		24.42
Total		38,047.85
Material put in place:		
Rock	cubic yards	23,209.9
Brush	do	29,009.8
Total	do	52,219.7
Average cost per cubic yard in place		$0.729

(*b*) *Building dams and shore protections* (*hired labor*).—This work was done under the direction of Mr. Byron Layton, overseer, who had dredge *Phœnix* and tender at his disposal. The dams built during 1895 at Wyaconda Bar, which are entirely of gravel, were successful in maintaining a channel in a place which has been for several years one of the worst obstructions in the river above St. Louis. The water was so low that the dams could not be built as high as is desirable with the side-dumping boats employed, and there was some waste of material owing to the shoal water and the difficulty in dumping the loads exactly where desired. The material used was a very heavy deposit of loose rock and gravel at the mouth of Wyaconda Creek, which was easily dredged and which exists in large quantities. It was found to answer well for shore protection, much of it being more like broken rock than gravel. The graveling of Dam 1 (sheet 66), in Canton Chute, was necessary, this dam being an important closing dam, with a head of from 5 to 6 feet of water against it. The gravel was found close by the site of the dam and was moved at small expense. The following is from Mr. Layton's report:

"On July 1, 1895, at Lower Bludsoes Crossing, an attempt was made to find suitable material for constructing a mud dam, but, being unsuccessful, this was abandoned, and on July 2 the dredge began digging gravel in Canton Chute and dumping along upper face of Dam 1 (sheet 66). This dam was filled in with gravel back to a distance of about 60 feet and up to low water. On July 18 the dredge removed a portion of a sunken barge at Canton Landing. From July 19 to August 25 and from September 5 to November 8 the dredge was engaged in digging gravel at the mouth of Wyaconda River, the material being used in constructing a series of dams along Missouri shore at Wyaconda Bar and in protecting Island 419. The work accomplished consisted in the construction of Dam 10 (sheet 66), located 2,100 feet above mouth of Wyaconda River, the dam being built to a length of 1,040 feet and to a

height of 3 feet above low water; Dam 9, located 1,000 feet above Dam 10, 700 feet in length and built to low water, and Dam 8, located 900 feet above Dam 9, length 400 feet, and built to low water. One thousand feet of Island 419 was protected to top of bank, height of bank being 10 feet, with a slope of 3 to 1; 400 feet to a 5-foot stage, and 2,000 feet to a 1-foot stage. The effect of the dams was manifest in the improvement of Wyaconda Crossing, securing 4 feet at low water.

"From May 12 to September 4 the steamer *Climax* was chartered as tender for dredge *Phœnix*. During remainder of season the new dredge tender *Ruth* was in service. On November 8 the works were closed for the season, and with the assistance of the *Vixen* the fleet was towed into the Des Moines Rapids Canal and laid up."

List of works constructed and of materials used during season of 1895 at Wyaconda Bar and Canton Chute.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Gravel.	Brush.
Sheet 66:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Dam 1, repaired	.....	.....	8,374.4	.....
Dam 8	400	.....	2,269.3	.....
Dam 9	700	.....	10,565	.....
Dam 10	1,040	3	13,796.5	.....
Shore protection, island 419	3,400	.....	10,017.7	2,303.8
Total	.....	.....	45,022.9	2,303.8

Financial statement for building dams and shore protections between Keokuk and Quincy during season of 1895.

Amount expended in field during calendar year 1895 (from distribution sheets)		$7,094.78
Add quota for general superintendence and office expenses		179.50
Add for use and deterioration of plant		2,155.07
Total		9,429.35
Material put in place:		
Brush	cubic yards	2,303.8
Dredged material	do	43,092.1
Total	do	45,395.9
Average cost per cubic yard for material and putting in		$0.157
Add for use and deterioration of plant		.047
Add for general superintendence and office expenses		.004
Average cost per cubic yard in place		.208

ENLARGEMENT AND REPAIR OF LEVEES BETWEEN WARSAW AND QUINCY.

This work was carried on under formal written contract, dated June 6 and approved June 15, 1895, with Casgrain & McDonald, of Chicago, and was under local charge of Mr. R. Munroe, inspector, from whose reports extracts follow below. The season was favorable for work, the water being low and the weather extremely dry. The contractors at first attempted to do the work mostly with their own plant and hired teams, but soon found that it would be impossible in this way to get the work done in season unless they doubled their force and greatly added to their plant. I made an estimate which I presented to them in the month of June, showing that with the time which they could safely consider as available to push the work, it would require a minimum of 140 teams, of all kinds, continuously at work, to accomplish the movement of the 600,000 cubic yards or more which their contract called for. About a month later they were notified by you to increase their force, but for some reason the additions came but slowly, and the highest number of teams reported as at work on any one day was but 146, falling down to 45 three days afterwards. The average number of teams for the 150 working days between June 22 and December 14, on the upper half of the levee between Warsaw and Canton, was but 41.4, and for the 132 working days between July 12 and December 14, on the lower half of the levee

between Canton and Quincy, the average was but 30 teams, or about half the force needed. It was thought at first the work might be carried on all winter, the soil being so dry there was nothing to freeze, in which case it would have been possible to utilize some of the time that my calculations had put down as unfit for work. Unfortunately, there was a heavy rain, followed by snow, late in November, and then a cold spell that froze the ground to a depth of 9 inches or more. In such light work as the reenforcement of the existing levee, this frost made good work impossible. In December there were heavy rains with mild weather, followed by freezing, which kept the ground in an unfit condition to work, and in consequence, on December 14, the contractors ceased work under orders from you.

The total amount of earth moved amounts to about 280,000 cubic yards of a total of 600,000. About 17 miles of a total of 39 miles are finished.

"Work on enlargement and repair of levees in Hunt and Lima Lake districts was commenced at Station 0, about 1 mile south of Warsaw, on June 19, 1895. Work was begun in Indian Grave district at station 2030, near head of Quincy Bay, on July 12, 1895. Drag scrapers and wheel scrapers were used. The material was earth, placed on the river side of the old levee, where it was possible to borrow material on that side. Where the material was borrowed on the land side it was placed on the land side of the old levee. Work was suspended December 14, 1895.

"There have been completed in the Hunt and Lima Lake districts 13.1 miles of levee, of which 12 miles have been accepted. In the Indian Grave district 3.7 miles have been finished and 2.5 miles accepted.

"The contract price for earthwork in the Hunt and Lima Lake districts is 8.95 cents per cubic yard, and in the Indian Grave district 10.95 cents.

"A small amount of masonry and riprap has been placed at the Bear Creek and Quincy Bay outlets, at a cost of $47.30."

Estimated earthwork to December 14, 1895.

Hunt and Lima Lake districts	cubic yards..	170,020.9
Indian Grave district	do....	96,645.6
Total	do....	266,666.5

Statement of expenditures.

Drainage	$47.30
Inspection, office expenses, etc	8,036.18
Earthwork	*25,799.56
Total to December 31, 1895	33,883.04

DREDGING QUINCY BAY.

An allotment of $15,000 was made by river and harbor act of August 17, 1894, from funds appropriated by sundry civil act of August 18, 1894. A project for dredging Quincy Bay was approved by the Secretary of War November 3, 1894, and the work was done under contract with A. J. Whitney, at 8.9 cents per cubic yard. Some repairs were made to the bulkhead at mouth of Whipple Creek, it being found necessary to do so to prevent the débris brought down by the creek in freshets from filling up the dredged areas.

The work at Quincy Bay was in local charge of Inspector C. W. H. Smith, from whose reports extracts follow:

"(*a*) *Dredging.*—Work of dredging in Quincy Bay, under contract with A. J. Whitney, was begun on April 9, 1895, with a plant consisting of dredge, tender, and two dump boats, to which were added two more dump boats in the latter part of June. Material was dumped on the Missouri side of the river, under Dam 1 (sheet 68), during the entire season, excepting a few days when the place was inaccessible on account of high winds, the material then being dumped at the Quincy city dumping grounds, south of the city.

"Commencing 300 feet south of the south end of the pile bulkhead on west side of bay, four cuts were carried northward 2,400 feet, making a channel 100 feet in width; also from this point three cuts were extended southward 1,500 feet to connect with the west channel of the bay bridge draw, making a channel 65 feet in width. On the east side of bay, between the Gem City sawmill and the railroad bridge, an area

* Includes retained percentage.

of 400 feet in width at north end, 75 feet at south end (in east channel of draw), and 900 feet in length was dredged to accommodate rafts for the mills.

"South of the railroad bridge a channel was dredged 1,800 feet in length, being 150 feet in width at the draw and 200 feet at the south end. Starting from a point on the edge of this channel, 50 feet south of harbor pile 5, and extending to the east shore, a pocket 350 feet in length was dredged for the benefit of lumbermen. Two bars were also removed along the east shore; one at the mouth of sewer emptying 135 feet north of harbor pile 3, and the other at sewer emptying 125 feet north of harbor pile 2.

"Work on this contract was suspended November 6, 1895.

Amount dredged from April 9 to November 6 (inclusive)	cubic yards	85,534.5
Cost of 85,534 cubic yards, at 8.9 cents per yard		$7,612.57

"(*b*) *Repairs to bulkhead in Quincy Bay.*—During the spring of 1895 several severe storms occurred, and for the first time since the construction of the bulkhead it was exposed to the full force of a flood in Whipple Creek. This creek with a slope of 50 feet or more to the mile, and bed of ledge rock, becomes at times a torrent, sweeping heavy bowlders and everything else before it. On one of these occasions, it filled the area inside the bulkhead and discharged over the top of it, exposing it to a head of from 6 to 8 feet of water. Under these circumstances it was found that the sandy gravel formation on which it was built was not firm enough to withstand the pressure, and two breaks occurred, one near the southwest corner and one midway in the south end. A small amount of rock was purchased in open market to repair these breaks. The broken bulkhead was pushed back into place and braced, and the hole washed under it was filled with rock and refuse from the neighboring sawmill, which furnished assistance not only with material, but with men.

"The following amounts of material were used in the repairs:

Rock	cubic yards	508.7
Gravel	do	400
Total	do	908.7

"In May, 1895, three small leaks under the bulkhead near the north end were repaired by the use of gravel banked up against the inside face, a few teams and scrapers being used to do the work.

"The bulkhead has well fulfilled its purpose in protecting the dredged channel between the upper and lower portions of the bay from the inevitable filling up which used to follow every considerable rain storm. It is evident, however, that it will have to be carefully watched and kept in order by slight repairs from time to time, the force of the flows in Whipple Creek being enormous and liable to attack the structure differently at different times."

Statement of expenditures.

Office expenses and preliminary surveys	$276.18
Repairs to bulkhead	514.46
Inspection	1,936.92
Dredging	7,612.57
Total	10,340.13
Average cost per cubic yard, including inspection	.11

Plant.—Considerable repair and construction work was performed at the Dry Dock and Lower Lock of the Des Moines Rapids Canal, details of which are given in my report of the canal.

Very respectfully, your obedient servant,

M. MEIGS,
United States Civil Engineer.

Lieut. Col. W. R. KING,
Corps of Engineers, U. S. A.

REPORT OF MR. S. EDWARDS, SUPERINTENDENT.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., January 1, 1896.

COLONEL: I have the honor to submit the following report of operations for improving the Mississippi River in the division in my local charge for the calendar year ending December 31, 1895.

QUINCY BRIDGE TO CLARKSVILLE.

Work on this division was carried on by hired labor and use of Government plant, towboat *Coal Bluff* and launch *Stella* doing the towing.

With the exception of a small amount of brush cut by hired labor, all material was bought in open market under due competition.

The work consisted in building dams, protecting caving banks, and in slight repairs to old work. A dredge was employed a short time in removing an obstruction at foot of Hickory Chute and a gravel and bowlder bar at mouth of Noix Creek. The work was carried on at Whitney Bar, Cave Hollow, below Hannibal, at Quincy, between Mundys Landing and foot of Hickory Chute, and at Louisiana. Orders to commence the season's operations were received April 1, 1895, and on April 3 towboat *Coal Bluff* was under steam; but considerable preliminary work being necessary, construction of dams and shore protections was not begun until April 15.

At Whitney Bar.—Whitney Bar is located about 6 miles above Hannibal. The river, from a point 3 miles above the bar to 4½ miles below, has for a great number of years been troublesome to navigation, and at times—in low water—almost impassable. The bad stretch is divided into two sections, known to river men as Upper Whitney and Lower Whitney. Though both places were about equally bad, it was thought best not to do any work on the upper reach until the lower reach had been fully improved. The work consisted in closing a gap in Dam 1 (sheet 70) 300 feet long and 21 feet deep and in lengthening the dam 800 feet. The Illinois shore opposite the dam for a length of 3,500 feet was then protected. This revetment was carried to top of bank, averaging about 10 feet above low water. Further improvements at this bar consisted in building nine wing dams and one closing dam. The closing dam is located at about the middle of the bar, and was built to prevent a cut-off forming through bar. Seven wing dams were built below the bar, running out from Missouri shore, one from Illinois shore opposite foot of bar, and one from Armstrong Island near its foot. At Swift Point, just below the series of dams on Missouri side, 1,800 feet of bank was protected and 525 additional feet of apron laid and loaded, the same to be extended up the bank at some future time. Extensive repairs were made to shore protection on Illinois shore above Hannibal Bridge and to Dam 9 (sheet 70), which had suffered much damage from ice during the preceding winter.

As regards length and height of works, as well as material put in each piece, I would respectfully refer you to the accompanying tables. As will be seen from such tables, most of the dams are low dams—that is, built to about a 2-foot stage. Two objects were had in view by this: First, to enable me to build as many dams as possible with a given amount of money; and second, to prevent a too violent movement of sand by the next high water, which higher dams would be likely to cause. That the improvements gave satisfactory results is best shown by frequent soundings taken. Before work was commenced soundings showed 2.5 to 3 feet on several reefs, referred to low water. As the work progressed the depth increased, and when the water fell to about 0 on Hannibal Bridge gauge, we had 5.5 feet of navigable water. No boats got aground here during the whole season, although some river men predicted that Lower Whitney would be the head of navigation.

Work in vicinity of Whitney Bar was carried on from April 15 to September 23.

At Cave Hollow.—The channel at this point has been very unstable, frequently changing from one side of the river to the other. In 1893 the channel favored the Illinois side and was very poor, but in the fall of that season it changed to the Missouri side and remained there during 1894. This being the best side, needing no shore protection, it was thought advisable to hold the channel there. A series of wing dams was proposed to be built on the Illinois side, commencing at the head of Island 444. Two of these dams were built, viz, Dam 4 (sheet 71), 685 feet long, and Dam 5 (sheet 71), 1,975 feet long. It is possible that the remainder of the dams proposed may be omitted for a number of years to come. A gravel bar opposite Dam 4 still prevents the formation of a first-class channel, and part of it should be removed by dredge at an early day.

Work in this locality was in progress from September 23 to October 29.

At Quincy.—Work was carried on from October 29 to 31, and consisted in extending Dam 1 (sheet 68) 30 feet, and in raising low portion of dam to 4 feet above low water.

From Mundys Landing to foot of Hickory Chute.—The work at this point consisted entirely in protecting caving banks. The following distances were protected, the heights being given in annexed table: At Mundys Landing, 3,260 feet; at Atlas Island, 1,920 feet; at towhead below Island 451, 600 feet; at Missouri shore below Island 451, 3,400 feet; at Island 452, 1,460 feet; at head of Hickory Chute, 1,822 feet; at Island 454, 2,250 feet, and at foot of Hickory Chute, 4,550 feet.

Work was carried on between May 20 and October 23.

At Louisiana.—A short distance above Louisiana Bridge is located the mouth of Noix Creek. Though a very small creek ordinarily, after heavy rains it in the space of two hours rises 9 or 10 feet. The deposit of sand, gravel, and rock in the Mississippi after a heavy rain is very considerable, and during one storm this spring the

bar at the mouth of the creek was extended 150 feet into the channel. Dredge *Phœnix* was put at work August 26, and by September 5 had removed the creek deposits, amounting to 3,407 cubic yards, and 335 cubic yards of loose rock projecting from channel side of bridge boom. To prevent the creek from depositing more gravel in the channel, a wing dam was built across it, starting at the railway embankment and running down stream in a curved direction, so as to deflect the stream.

On October 31 the season's work was discontinued and the fleet laid up for the winter in Quincy Bay.

In general.—The total amount of work accomplished was 12,666 linear feet of dams and 26,037 linear feet of shore protection, in which, with the needed repairs, were used 65,233.7 cubic yards of rock and 100,902.2 cubic yards of brush; total, 166,135.9 cubic yards.

The season throughout was marked by a very low stage of water, causing delay in getting material, especially brush. The camps mostly being located away from the channel, the towboats had to do much extra running, it being necessary to load the barges light. Notwithstanding the low stage, however, there was not one case of a boat aground on this division this season. There were several very crooked places, but the navigable water being sufficient it was thought best not to disturb the bottom. At such places buoys were placed to assist boats in making the turns, which, especially at night, proved a great success. From conversation held with river men on this subject, I feel inclined to recommend the use of buoys more extensively than heretofore, and would suggest that a regular system be adopted; for instance, that boats going downstream go to the left of white buoys, to the right of white-and-black buoys. Where work is being carried on, and where the channel is apt to change quickly, some such method would be gratefully received by pilots.

I take pleasure in extending my thanks to Overseer C. C. Seymour, and to Receivers of Materials Ed. H. Jones and C. H. Sisson for their faithful services during the past season.

List of works constructed and repaired, and of materials used, during season of 1895, between Quincy Bridge and Clarksville.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
	Feet.	*Feet.*	*Cu. yds.*	*Cu. yds.*
Sheet 68: Wing Dam 1, extended and repaired	.....	4.	402.4	519
Sheet 70:				
Wing Dam 1, extended and repaired	800	4.5	5,629	9,602.2
Closing Dam 5, repaired	.....	.....	155.9	.....
Wing Dam 9, repaired	.....	.....	251.3	308.3
Wing Dam 13	960	4.5	2,784.1	7,049.9
Wing Dam 14	1,400	4.5	3,738.3	8,856.9
Closing Dam 15	205	4.5	288	289
Wing Dam 16	940	2	925.7	2,153.4
Wing Dam 17	900	2	895.7	3,393.7
Wing Dam 18	420	4.5	1,761.2	3,931.4
Wing Dam 19	924	2	753	2,253.3
Wing Dam 20	630	2	634.6	1,706.5
Wing Dam 21	1,275	2	2,003	5,402.1
Wing Dam 22	1,000	2	1,819.9	5,926.9
Shore protection, Island 437	3,500	7.5	4,086.9	2,696.2
Shore protection, Whitney Bar, apron only	950	2	180.5	460.4
Shore protection, Swift Point	2,325	(*)	2,021.9	1,195.8
Shore protection, Island 439, repaired	.....	.....	154.3	.....
Shore protection, Illinois shore above Hannibal Bridge, repaired	.....	.....	881.4	865.6
Sheet 71:				
Wing Dam 4	685	4.5	2,605	6,001.9
Wing Dam 5	1,975	3.5	4,041.1	10,470.6
Sheet 73:				
Shore protection at Mundys Landing	3,260	(†)	2,833.5	3,660.1
Shore protection, Atlas Island	1,920	6 to 10	2,604	2,715.2
Shore protection, towhead below Island 451	600	12	667	1,510.5
Shore protection, Missouri shore below Island 451	3,400	8	5,275.5	3,087.9
Sheet 74:				
Shore protection, Island 452	1,460	10	1,901.3	2,415.2
Shore protection, Missouri shore, head Hickory Chute	1,822	11	3,144.7	2,621.3
Shore protection, Island 454	2,250	10	4,272.4	3,310
Shore protection, Missouri shore, foot of Hickory Chute	4,550	10	7,861.1	6,772.1
Sheet 75: Wing Dam 5, Noix Creek	482	6	661	1,726.8
Total	.....	.....	65,233.7	100,902.2

*1,050 feet of this shore protection is 14 feet high, 750 feet is 8 feet high, and 525 feet apron only.
†6 feet of this shore protection is 8 feet high, and 2,874 feet 4 feet high.

Financial statement for work between Quincy Bridge and Clarksville, performed by hired labor during season of 1895.

Amount expended in field during calendar year 1895 (from distribution sheets)	$91,290.93
Deduct cost of dredging	810.83
Total	90,480.10
Add quota of general superintendence and office expenses	2,309.66
Add for use and deterioration of plant	7,361.34
Total	100,151.10
Material put in works:	
Rock, cubic yards	65,233.7
Brush, do	100,902.2
Total, do	166,135.9
Average cost per cubic yard:	
On barges	$0.331
For towing and putting in place	.214
For general superintendence and office expenses	.014
For plant	.044
Average cost per cubic yard in place	.603

CLARKSVILLE TO HAMBURG.

The work was carried on under formal written contract with Jacob Richtman, dated October 18, 1894. Prices per cubic yard in place: Rock, $1.20; brush, 10 cents.

The work was in local charge of J. A. Macfie, inspector, to whom much credit is due for faithful and intelligent management. Work was begun April 9, 1895, and discontinued October 26, the contract having been completed. With the exception of building one dam, 2,000 feet long, the work consisted in protecting caving banks by building revetment of rock and brush. A slope of 1 on 2 was observed, being slightly increased on very sandy banks. The total amount of new work completed was as follows: Shore protection, 15,085 linear feet; dams, 2,000 linear feet; shore protection repaired, 600 feet. The work was carried on at the following places (lengths and heights, as well as material used, are given in annexed table): Dam 2 (sheet 78), 2,000 feet long, located at foot of Tisdales Towhead, and running about parallel to Missouri shore. This dam was built to cut off a strong cross current, which made rafting at this point very difficult. No trouble was reported after dam was completed. Opposite Island 470, where revetment had undermined and caved in, 600 linear feet of shore protection was repaired. The Illinois shore was protected opposite Islands 470 and 472, as was also head of Island 472. On Missouri shore Thomas Chute was protected, commencing near head; also small towhead in chute and the main shore below Amaranth Island.

All the above places were cutting badly, thowing great quantities of sand into the river.

List of works performed and of materials used during season of 1895, under contract with Jacob Richtman, between Clarksville and Hamburg.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
	Feet.	*Feet.*	*Cu. yds.*	*Cu. yds.*
Sheet 78:				
Trailing Dam 2, from foot of Tisdales Towhead	2,000	4.5	2,727.5	7,132.8
Shore protection, Illinois shore opposite Island 470, repaired	600	8	354.6	.....
Shore protection, Illinois shore, opposite Island 470	1,665	9 to 12	5,149.3	5,054
Shore protection, Illinois shore, opposite Island 472	900	10	1,394.4	1,803.5
Shore protection, Island 472	640	10	871.7	1,128.7
Shore protection, towhead Thomas Chute	80	13	221.3	353.3
Shore protection, Missouri shore, Thomas Chute	6,150	11 to 13	10,368.2	10,589.4
Sheet 77: Shore protection, Missouri shore, below Amaranth Island	5,650	10	8,452.7	10,169.5
Total	.....	.....	25,539.7	36,131.2

Financial statement for work between Clarksville and Hamburg, performed under contract during 1895.

Amount paid contractor	$39,060.76
Cost of local inspection, etc	1,631.28
Add quota of general superintendence and office expenses	1,029.50
Add plant charge	79.18
Total	41,800.72

Material put in works:		
Rock	cubic yards	29,539.7
Brush	do	36,131.2
Total	do	65,670.9
Average cost per cubic yard in place		$0.637

Very respectfully, your obedient servant,

S. EDWARDS, *Superintendent.*

Lieut. Col. W. R. KING,
Corps of Engineers, U. S. A.

REPORT OF FIRST LIEUT. CHARLES KELLER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., January 14, 1896.

COLONEL: I have the honor to submit the following report of improvement work performed between Hamburg and the mouth of Missouri River during the calendar year ending December 31, 1895:

HAMBURG TO CAP AU GRIS.

All work in this section of river was done under contract with Jacob Richtman, dated October 18, 1894, under project approved by the Chief of Engineers August 21, 1894, and an allotment of $50,000.

Operations which had been suspended at close of calendar year 1894, on account of stress of weather, were resumed on March 11, 1895, under local inspection of Mr. I. Mathewson. The work consisted in repairs to dams and construction of shore protection, as follows:

Dams 2 and 4 (sheet 79) were repaired and placed in good condition. Work of repairing and raising Dam 5 was continued, having been partly accomplished during season of 1894. Dam 14 was seriously affected by a strong parallel current which was cutting out in front of dam. This was stopped by putting in two small spurs, which left the dam in good condition. Dam 16, an old pile dam, had been considerably injured by the washing out of the shore protection at Missouri shore and several hundred feet of the main dam. A new shore protection was constructed and an apron and second course were put in across gap in dam. Shore protection was constructed on Island 489 for a length of 635 feet, rocked to top of bank and finished. Two thousand and twenty-five linear feet of shore protection were constructed on Island 490, requiring slight addition of rock to finish to top of bank. Shore protection on Island 491 was constructed, for a length of 715 feet, to an elevation of 5.5 feet.

The full quantities of rock and brush provided for under the contract having been put in place, work was suspended on May 21, 1895, and contract closed.

The prices paid for materials in place under above contract, were $1.20 per cubic yard for rock, and 10 cents per cubic yard for brush.

Contract of 1895.—Under an allotment of $50,000, in accordance with project approved April 17, 1895, a contract was entered into with James Short, under date of June 11, 1895, for the continuation of improvement of this section of river by construction of dams and shore protections. The prices to be paid for materials in place are 94 cents per cubic yard for rock and 15 cents per cubic yard for brush. No work had been done under this contract up to close of calendar year 1895.

List of works constructed and repaired, and of materials used, during the season of 1895, under contract with Jacob Richtman, between Hamburg and Cap au Gris.

Designation.	Length.	Material.	
		Rock.	Brush.
Sheet 79:	*Feet.*	*Cu. yds.*	*Cu. yds.*
Dam 2, repaired	.....	99	50
Dam 4, repaired	.....	142.6	150
Dam 5, repaired	.....	2,106.9	596.3
Dam 14, repaired	.....	2,540.9	1,691.2
Dam 16, repaired	.....	2,186.5	2,850.7
Shore protection, Island 489	635	2.109.2	1,184.1
Shore protection, Island 490	2,025	7,235	4,255.5
Shore protection, Island 715	715	2,161.3	2,511.3
Total	.....	18,581.4	13,289.1

Financial statement for work between Hamburg and Cap au Gris, performed under contract with Jacob Richtman during seasons of 1894 and 1895 (entire contract of 1894).

Amount paid contractor		$39,313.30
Cost of local inspection, etc		1,407.48
Add for general superintendence and office expenses		992.77
Total		41,713.55
Material put in works:		
Rock	cubic yards	30,926
Brush	do	22,021
Total	do	52,947
Average cost per cubic yard in place		$0.788

CAP AU GRIS TO ILLINOIS RIVER.

Contract of 1894.—At close of calendar year 1894, work was in progress under contract with Jacob Richtman, dated October 18, 1894, under an allotment of $50,000, in accordance with project approved August 21, 1894. This work was continued without interruption until March 28, 1895, when contractor suspended operations. Work was resumed in May and continued until contract was completed, August 14, 1895.

The above work consisted in the construction and repair of dams and shore protections as follows: Shore protection at Auers Landing, commenced in 1894, was completed. The total length of same is 1,630 feet. Shore protection was constructed around head of Iowa Island for a length of 725 feet. Slight repairs were made to Dam 4 (sheet 83). Dam 7 was extended 189 feet and original dam thoroughly repaired, the sunken portion being raised to proper level. Work on Dam 9, which commenced in season of 1894, was continued.

New works constructed under this contract were Dam 10, from Island 523, Dam 13 from Island 521, and Dam 11 from lower end of Island 521. This latter dam has four spurs, the aggregate length of which is 620 feet, the main dam being 2,590 feet long.

Contract of 1895.—Under an allotment of $50,000, in accordance with project approved April 17, 1895, a contract was entered into with James Short, under date of June 11, 1895, for the continuation of improvement of this stretch of river. The prices paid for materials in place were, 87 cents per cubic yard for rock and 10 cents per cubic yard for brush. Work under this contract was commenced August 17, 1895, and continued until December 10, 1895, when operations were suspended for the season. The following work was accomplished:

Repairs were made to Dam 21 (sheet 82), Dam 8 (sheet 83), and to shore protection at Mound Landing and Auers Landing. Work on Dam 91 (sheet 83) was continued. The following dams were constructed: Dams 14 and 16, on channel side of Masons Island, and Dam 17, on Missouri shore opposite Masons Island.

Shore protection was constructed on the Missouri shore opposite Masons Island for a length of 1,300 feet and at the head of Dardenne Island for a length of 450 feet.

The total quantity of material put in under above contract was 35,000 cubic yards, leaving about 25,000 cubic yards yet to be finished.

Further details as to character and extent of the work done are given in "outline

sketches showing works constructed," which have been submitted, and in the following table:

List of works constructed and repaired, and of materials used, during the season of 1895, under contracts with Jacob Richtman and James Short, between Cap au Gris and mouth of Illinois River.

Designation.	Dimensions.		Material.	
	Length.	Height above low water 1864.	Rock.	Brush.
Sheet 82:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Dam 2, repaired	.....	.....	1,087.5	509.8
Shore protection, Dardenne Island	450	.....	1,706.4	1,114.4
Sheet 83:				
Dam 4, repaired	.....	.....	262.3	282.3
Dam 7, extended and repaired	189	.....	949.1	1,570.9
Dam 8, repaired	.....	.....	352.6	220
Dam 9, closing dam	950	4	4,056.8	5,629.2
Dam 10, wing dam	1,150	5	2,780.3	2,881.8
Dam 11, wing dam	3,210	5	4,941.5	6,304.7
Dam 13, wing dam	380	4	2,795.2	3,885.3
Dam 14, wing dam	900	4	3,071.1	4,481.3
Dam 16, wing dam	540	4	3,622.6	4,670.9
Dam 17, wing dam	600	4	1,686.7	1,706
Shore protection, Auers Landing	1,405	.....	6,387.9	4,498.2
Shore protection, Iowa Island	725	.....	2,459.5	2,045.7
Shore protection opposite Masons Island	1,300	.....	4,213.9	3,681.5
Shore protection, Mound Landing, repaired	.....	.....	126.9	292
Total	.....	.....	40,500.3	43,774

Financial statement for work between Cap au Gris and mouth of Illinois River, performed under contract of 1894 with Jacob Richtman, during season of 1895 (entire contract.)

Amount paid contractor	$27,970.30
Cost of local inspection, etc	1,218.50
Add for general superintendence and office expenses	842.27
Add for use and deterioration of plant	65.86
Total	30,096.93
Material put in works:	
Rock, cubic yards	23,048.5
Brush, do	23,169.5
Total, do	49,218
Average cost per cubic yard in place	$0.611

Financial statement for work between Cap au Gris and mouth of Illinois River, performed under contract of 1895 with James Short, during season of 1895.

Amount paid contractor	$15,249.18
Add retained percentage	1,694.35
	16,943.35
Cost of local inspection, etc	1,076.90
Add for general superintendence and office expenses	456.02
Add for use and deterioration of plant	61.42
Total	18,537.87
Material put in works:	
Rock, cubic yards	17,451.8
Brush, do	17,604.5
Total, do	35,056.3
Average cost per cubic yard in place	$0.529

ILLINOIS RIVER TO MISSOURI RIVER.

Under an allotment of $95,000, in accordance with project approved April 17, 1895, work was carried on in this section by hired labor and the use of Government plant, the materials being secured by purchase in open market and by formal contract.

The method of improvement was the same as that followed in former years upon the Upper Mississippi River, consisting of spur and closing dikes of rock and brush to contract the channel, and the use of like material in the protection of caving banks.

Work for the season was confined to the vicinities of Grafton, Piasa Island, and Maple Island. As far as possible the order of work was chosen with a view to giving immediate relief to navigation. At no time during low water were boats subject to the delays and difficulties of former years, and at close of season's operations there was decided evidence that a considerable improvement is being effected by the new works.

Vicinity of Grafton.—Construction of wing dams from Missouri shore opposite Grafton, and from Illinois shore below Grafton, a trailing dam from the foot of Island 526, closing off the chute between Slim Island and the Missouri shore, and the construction of 1,098 linear feet of shore protection on Island 526 were all found necessary for the securing of a permanent channel on lines of the proposed project in this vicinity.

In detail the works constructed in above-mentioned localities are as follows:

One wing dam, No. 15; one trailing dam, No. 12, and one piece of shore protection on Island 526 (sheet 83). Seven wing dams, Nos. 24, 25, 26, 28, 29, 30, and 31; closing dam No. 32, and 450 linear feet of shore protection on Portage Island.

Vicinity of Piasa Island.—The following work was accomplished: Five wing dams, Nos. 5, 21, 22, 23, and 27, were constructed, and Dam 4 extended, all on the Missouri shore, and 828 feet of shore protection were constructed at Riverside Park.

The above-described work completes the project in that vicinity and secures a permanent deep channel where in former years it was very shoal and crooked.

Vicinity of Maple Island.—Three pieces of shore protection were constructed in this vicinity, viz, a length of 2,080 feet on Missouri shore opposite Maple Island; 1,258 feet at head of Mobile Island, and 2,300 feet on Illinois shore below Wood River. The shore protection below Wood River when completed will extend to a point opposite mouth of Missouri River.

An examination was made in vicinity of Maple Island during June, 1895, and maps were submitted.

The season's work of construction extended from June 10, 1895, to November 1, 1895. The steamer *J. G. Parke,* steam launch *Iris*, barges, quarter boats, etc., all belonging to the United States, were employed on the work during the season.

Further details in regard to character and extent of the work done are shown in my "outline sketches showing work accomplished," already transmitted to you, and the following tables:

List of works constructed and of materials used during season of 1895, between Illinois River and Missouri River.

Designation.	Dimensions.		Material.	
	Length.	Height above low water, 1864.	Rock.	Brush.
Sheet 83:	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*
Trailing dam 12	1,858	6	13,143.1	16,649.8
Wing dam 15	250	6	1,073.5	1,080.9
Shore protection, Island 526	1,098	.....	1,518.5	1,450.1
Sheet 84:				
Wing dam 4, extended	200	.....	2,354.4	3,669.2
Wing dam 5	1,900	4	3,688	6,328.4
Wing dam 21	2,030	4	3,166.4	5,680.7
Wing dam 22	1,750	4	2,690.6	4,902.3
Wing dam 23	2,380	4	4,998	7,651.1
Wing dam 24	700	4	2,009.7	3,752.2
Wing dam 25	400	5	595.9	1,834.5
Wing dam 26	860	4	2,044.9	4,551
Wing dam 27	2,020	4	3,396.5	7,205.7
Wing dam 28	500	4	2,923.1	6,500.4
Wing dam 29	1,590	5	1,566.5	4,862.2
Wing dam 30	900	4	966	2,881.1
Wing dam 31	1,470	4	3,438.6	7,634
Closing dam 32	470	4	1,322.7	2,317.4
Shore protection, Riverside Park	828	.....	1,599.1	1,466.8
Shore protection, Missouri shore opposite Maple Island	2,080	.....	4,721.3	3,303.7
Shore protection, Mobile Island	1,258	.....	2,961	3,303.1
Shore protection, Illinois shore below Wood River	2,300	.....	5,404.9	5,068.1
Shore protection, Portage Islands	450	.....	978.5	770
Total	.....	.....	66,561.2	102,862.7

Financial statement for work of constructing dams and shore revetments between Illinois River and Missouri River, performed by hired labor during the season of 1895.

Amount expended in field during calendar year 1895	$84,023.22
Add for retained percentage	1,534.93
Net cost of field work	85,558.15
Add quota of general superintendence and office expenses	2,125.79
Add for use and deterioration of plant	6,694.41
Total	94,378.35

Material put in works:		
Rock	cubic yards	66,561.2
Brush	do	102,862.7
Total	do	169,423.9

Average cost per cubic yard:	
On barges	$0.287
For towing and putting in place	.218
For general superintendence and office expenses	.013
For plant	.039
Average cost per cubic yard in place	.557

Very respectfully, your obedient servant,

CHARLES KELLER,
First Lieutenant, Corps of Engineers.

Lieut. Col. W. R. KING,
Corps of Engineers, U. S. A.

REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER, ON PLANT.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., January 18, 1896.

COLONEL: I have the honor to present the following report on the floating stock or plant belonging to the improvement of the Mississippi River between the mouth of the Missouri River and Minneapolis for the calendar year ending December 31, 1895.

In this report "good" is in fine condition, wanting slight repairs or none; "fair" requires extensive repairs or such as are advisable; "bad" should be condemned or rebuilt. Pieces condemned are omitted.

The plant in question is as follows: 1 large towboat (*Coal Bluff*), fair; 2 medium-sized towboats (*Fury* and *Alert*), fair; 1 medium-sized towboat (*Vixen*), good; 2 small towboats (*Mac* and *Ruth*), good; 6 steam launches (*Lucia*, *Emily*, *Ada*, *Elsie*, *Iris*, and *Louise*), good; 1 small steam launch (*Florence*), good; 2 small naphtha launches (*Edith* and *Myra*), good; 1 small naphtha launch (*Dart*), fair; 1 dredge (*Vulcan*), fair; 1 dredge (*Phœnix*), bad; 1 dump, good; 5 dumps, bad; 3 steam drill boats, good; 1 suction dredge, good; 2 pile drivers, good; 2 pile drivers, fair; 10 large quarter boats, good; 1 large quarter boat, fair; 1 large quarter boat, bad; 13 small quarter boats, good; 2 small quarter boats, fair; 4 small quarter boats, bad; 2 large office boats, good; 13 small office boats, good; 7 grasshoppers good; 3 grasshoppers, fair; 3 grasshoppers, bad; 1 derrick boat, good; 1 store boat, bad; 1 boathouse, good; 5 large model barges, fair; 1 large model barge, good; 76 large barges, good; 15 large barges, fair; 1 large barge, bad; 9 small barges, good; 2 small barges, fair; 6 small barges, bad; and a large number of skiffs, loading boats, powder boats, and pontons in good condition. To the snagboat service belongs the side-wheel steamer *General Barnard*, fair, and stern-wheel steamer *J. G. Parke*, fair.

The Des Moines Rapids Canal has a small plant consisting of 1 steam launch (*Stella*), good; 1 dredge (*Ajax*), good; 4 dumps, good; 1 large barge, good; 1 small barge, good; 1 small barge, fair; 2 small barges, bad.

During the year, under approved projects, considerable additions and repairs to plant were made.

There were built at the dry dock at Des Moines Rapids Canal, 1 small towboat (*Ruth*), 1 large quarter boat, 2 small office boats, 3 large barges, and 1 small barge; and there were rebuilt 2 steam launches (*Stella* and *Lucia*), and 1 towboat (*Vixen*).

There were built at Fountain City, 1 large quarter boat, and 8 large barges; there were rebuilt 1 large quarter boat, 1 large barge, and 1 dump.

Considerable repairs were made to snag boats *General Barnard* and *J. G. Parke;* to towboats *Fury* and *Alert*; to launches *Louise, Elsie, Emily,* and *Ada*; to dredges *Phœnix* and *Vulcan*; to 1 drill boat, 1 derrick boat, 2 large barges, and 2 small quarter boats. Nominal repairs were made to many pieces.

The construction and repair work at the dry dock was done under supervision of Mr. M. Meigs, United States civil engineer; that at Lacrosse and Fountain City under the supervision of Mr. W. A. Thompson, superintendent.

Very respectfully, your obedient servant,

C. W. DURHAM,
Assistant Engineer.

Lieut. Col. W. R. KING,
Corps of Engineers, U. S. A.

REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 2, 1896.

COLONEL: I have the honor to present a brief preliminary report of operations between Missouri River and Minneapolis during the second half of the fiscal year ending June 30, 1896, as collated from reports of assistants in local charge. Full reports are made by calendar years.

St. Paul to Minneapolis.—In local charge of Assistant Engineer J. D. Du Shane. The amount available being insufficient to commence construction of Lock and Dam No. 2, no construction work was done. A part of the land needed for dam and lock sites has been purchased.

St. Paul to Lake Pepin.—In local charge of Assistant Engineer J. D. Du Shane. Construction of dams and shore protections was not commenced on account of unfavorable stage of water. Hydraulic Dredge No. 14 commenced operations May 8, and continued to close of fiscal year at Island 15 and Franklin Coulee. It is estimated that 33,000 cubic yards of material was moved by the dredge and deposited between dams at a distance of from 400 to 600 feet.

Reeds Landing to Genoa.—In local charge of Assistant Engineer W. A. Thompson. No work was done in construction of dams and shore protections, the stage of the water being unfavorable. Operations in opening quarry at Britts Landing and in erecting cable-hoist machinery were carried on in May and June. Dredging, reported under head of snag boats and dredges, was performed at Big Bend in Coon Slough.

Dubuque to Clinton.—In local charge of Assistant Engineer J. C. McElherne. Under contract with Albert Kirchner, approved June 29, 1895, running to June 30, 1896, and extended to July 31, 1896, construction of dams and shore protections was resumed April 13, 1896, and temporarily suspended on May 9, owing to high water. A closing dam across chute between Islands 281 and 282, and a wing dam running out from shore opposite Island 282, were built, and about 1,700 feet of shore protection on towhead at Santa Fe was repaired.

There were put in above-mentioned work 5,483.1 cubic yards rock and 4,283.9 cubic yards brush.

Rock Island Rapids.—On March 26, 1896, Drill Boat No. 6, with double crew, was set at work on Lower Chain and remained there until close of fiscal year. Dredge *Ajax* was employed at various points in removing broken rock from April 6 to May 11, at which latter date she was laid up on account of high water. Work on Dams 17 and 18 was resumed April 6 and temporarily suspended May 11, owing to unfavorable stage of water. One thousand two hundred and nine and two-tenths cubic yards of rock was broken up by the drill boat. The dredge removed 3,525 cubic yards of rock, the greater part of which was blasted in 1895. The material dredged, together with 709.4 cubic yards of rock purchased, was placed in the dams.

Rock Island to Muscatine.—In local charge of Assistant Engineer C. W. Durham. Under contract with Patterson Bros., approved March 25, and running to December 31, 1896, the construction of dams was carried on in vicinity of mouth of Rock River from May 9 to close of the fiscal year. A closing dam from Credit Island to the Davenport shore was built, as were also three wing dams running out from Credit Island.

There was placed in above work 8,826.7 cubic yards rock and 8,666.8 cubic yards brush.

Flint Creek to Iowa River.—In local charge of Assistant Engineer C. W. Durham. Levee construction was carried on in January, March, April, May, and June, under contract with M. H. King, approved September 7, 1895, and annulled April 7, 1896; under contract with Edward Callahan, approved May 23, 1896, and running to December 31, 1896, and under agreements with various parties. Eight miles of levee was completed and considerable progress was made on 14 miles additional. Amount of earthwork performed, 121,453 cubic yards. In February, 1896, 600 linear

feet of shore protection was constructed along the right bank of the Iowa River for levee preservation. Three hundred and seventy-seven and four-tenths cubic yards rock and 336.9 cubic yards brush were put in place.

Keokuk to Quincy.—In local charge of Mr. M. Meigs, United States civil engineer. Work in this section of river was performed by hired labor and use of Government plant. During last two weeks of April dredge *Phœnix* was employed in removing loose rock, sand, and gravel from the channel above and below the Keokuk Bridge and in vicinity of Keokuk steamboat landing. Five hundred and forty-one cubic yards of rock was removed and 126 cubic yards of sand and gravel. In April and May some repairs were made to Dam 2 (sheet 66) and to shore protections above Quincy Bridge, near Quincy Railway Dike and at Island 418. Four thousand one hundred and four cubic yards rock and 2,352.1 cubic yards brush were put in this work.

Quincy Bay.—In local charge of Mr. M. Meigs, United States civil engineer. In January and February some repairs were made by use of hired labor to the bulkhead at Whipple Creek. One thousand one hundred and eighteen and five-tenths cubic yards rock was used for this purpose.

Warsaw to Quincy.—In local charge of Mr. M. Meigs, United States civil engineer. Work in enlarging and strengthening levees between Warsaw and Quincy was carried on during the first six months of the year under contract with Casgrain & McDonald, approved June 15, 1895, running to June 30, 1896, and extended on account of high water to November 1. On the Hunt and Lima Lake levees 65,605 cubic yards earthwork was performed, and on the Indian Grave levee 133,404 cubic yards. Levee protection was made at various points, in which 3,255 cubic yards rock and 276 cubic yards brush were used.

Hamburg to Cap au Gris.—In local charge of First Lieut. Charles Keller, Corps of Engineers. Under contract with James Short, approved June 19, 1895, running to June 30, 1896, and extended to October 15, 1896, work in construction of dams and shore protections was resumed April 1, 1896, and continued to close of fiscal year, with one month's interruption owing to high water. Dam 14 (sheet 79) was repaired, Dams 4 (sheet 80) and 17 (sheet 79) were built, and Dam 5 (sheet 80) was commenced. About 1,600 linear feet of shore protection was laid on Island 487.

There were put in place 8,332 cubic yards rock and 11,956 cubic yards brush.

Cap au Gris to Illinois River.—In local charge of First Lieut. Charles Keller, Corps of Engineers. Under contract with James Short, approved June 19, 1895, and running to June 30, 1896, work in construction of dams and shore protections was resumed March 1, 1896, and continued until completion of contract, May 30. Repairs were made to shore protection at Mound Landing, Iowa Island, and Island 526, the aggregate length of which is 3,966 feet. Dams 18 to 23 (sheet 83) were built and Dam 9 was completed.

There were put in place 22,898 cubic yards rock and 24,495 cubic yards brush.

Very respectfully, your obedient servant,

C. W. DURHAM, *Assistant Engineer.*

Lieut. Col. W. R. KING,
Corps of Engineers, U. S. A.

X 3.

OPERATING AND CARE OF DES MOINES RAPIDS CANAL AND DRY DOCK.

The Des Moines Rapids Canal was open for navigation 237 days, during which time there passed through it 789 steamboats and 313 barges, carrying 25,270 passengers, 40,948 tons of merchandise, and 45,176 bushels of grain. There also passed through the canal 116,874,111 feet B. M. of lumber, 30,824,000 feet of logs, 46,122,000 shingles, and 34,448,534 laths.

The expenses of operating and caring for the Des Moines Rapids Canal and Dry Dock, including dredging and repairs to gates, machinery, and plant, have been during the past year $37,555.21. These expenses are provided for by an indefinite appropriation made by act of March 3, 1881. While this canal is a very important highway of commerce, I regret that the cost of operating it appears to be unnecessarily great. In my opinion it is a great mistake to install costly hydraulic or steam machinery on such canals for the purpose of operating gates and wickets. By means of suitable hand power, aided if necessary by

the crews of rafts and vessels for whose sole use the canal has been built at great expense, the gates and wickets could be opened as rapidly as it would be safe to move them, and the engineers and other more costly employees could be dispensed with, and a very considerable annual expense for repairs and renewals of broken and worn out machinery could be saved.

I recently timed a lockage on the Muscle Shoals Canal and found that it occupied but fifteen minutes from the time the boat entered until it moved out of the lock. About one-half of this time was occupied in emptying the lock chamber, and this part of the operation could not be shortened by any application of machinery.

Possibly an amount of traffic like that at Sault Ste. Marie may justify the use of machinery for operating the gates, but not on any ordinary canal.

The machinery being already installed on this canal, I am not prepared to recommend its abandonment at this time, though in case it should require extensive repairs or renewals at any time, the question of dispensing with it should be duly considered.

During the year nominal repairs were made to lock gates and lock machinery. Dredging to the amount of 48,128 cubic yards of material was performed during the year, which makes the aggregate taken from the canal since June 30, 1878, 1,047,481 cubic yards.

The dry dock was in constant use, and at times, when not required for repairs to portions of the Government plant, boats and barges belonging to private parties have been docked and repaired. The dockage fees collected from private parties during the fiscal year amounted to $568.75.

Abstract of appropriations.

By act approved—	
April 30, 1878	$7,500.00
June 18, 1878 (allotment)	32,500.00
March 3, 1879	40,000.00
June 14, 1880	30,000.00
March 3, 1881, for fiscal year ending—	
June 30, 1882	45,000.00
June 30, 1883	75,000.00
June 30, 1884	47,000.00
June 30, 1885	40,500.00
June 30, 1886	43,000.00
June 30, 1887	44,000.00
June 30, 1888	42,000.00
June 30, 1889	39,000.00
June 30, 1890	43,837.97
June 30, 1891	43,995.80
June 30, 1892	44,000.00
June 30, 1893	58,000.00
June 30, 1894	56,652.49
June 30, 1895	48,599.05
June 30, 1896	37,555.21
Total	818,140.52

Money statement.

July 6, 1895, balance on hand		$2,218.88
June 30, 1896, amount drawn from Treasury during fiscal year, under indefinite appropriation		36,500.00
		38,718.88
June 30, 1896, amount expended during fiscal year		37,555.21
June 30, 1896, balance on hand		1,163.67

List of vessels docked in the dry dock at the Des Moines Rapids Canal during the fiscal year ending June 30, 1896.

Designation.	Date of entering dock.	Date of leaving dock.	Remarks.
	1895.	1895.	
Steamer Ruth	.....	July 26	Built new.
Steamer Marion	.....	Aug. 15	Do.
Steamer Lucia	Aug. 15	....do ...	
Flat F	....do ...	....do ...	
Steamer Silver Crescent	....do ...	Aug. 16	Owned by private parties.
Steamer St. Paul	Aug. 20	Aug. 23	Do.
Flat No. 79	Aug. 23	Aug. 31	
Grasshopper No. 142	....do ...	....do ...	
Steamer Ruth	Aug. 26	Aug. 26	
Dump boat No. 1	Aug. 31	.....	Broken up.
Dump boat No. 6	....do ...	.....	Do.
Steamer Climax	Sept. 5	Sept. 6	Owned by private parties.
Barge Comfort	Sept. 6	Sept. 7	Do.
Office boat No. 85	Sept. 13	Sept. 14	
Steamer General Barnard	Sept. 23	Sept. 24	
Steamer Marion	Sept. 27	Sept. 28	
Coal flat No. 63	.....	Nov. 4	Built new. Used old bottom.
Steamer Coal Bluff	Nov. 4	Nov. 11	
Model barge No. 87	....do ...	....do ...	
Flat No. 160	....do ...	....do ...	
Flat No. 153	....do ...	Nov. 16	
Steamer Lucia	Nov. 11	Nov. 20	
Flat No. 157	Nov. 16	....do ...	
		1896.	
Dredge Phœnix	Nov. 20	Mar. 17	Rebuilt.
Steamer J. G. Parke	....do ...	Mar. 10	
	1896.		
Steamer Silver Crescent	Mar. 10	Mar. 14	Owned by private parties.
Steamer General Barnard	Mar. 18	Mar. 26	
Pile Driver No. 104	Mar. 17	Mar. 31	
Steamer Pittsburg	Mar. 31	Apr. 2	Do.
Steamer St. Paul	Apr. 3	Apr. 7	Do.
Dump boat No. 7	.....	Apr. 16	Built new.
Dump boat No. 8	.....	....do ...	
Steamer Pittsburg	Apr. 16	Apr. 17	Owned by private parties.
Steamer Lily	Apr. 18	Apr. 18	United States light-house tender.
Steamer Lily	Apr. 21	Apr. 21	Do.
Flat No. 157	Apr. 27	Apr. 28	
Canal dump boat D	May 12	May 16	
Dump boat No. 4	Apr. 28	.....	Broken up.
Dump boat No. 2	Apr. 18	.....	Do.
Canal dump boat B	May 16	May 25	
Steamer Pittsburg	June 7	June 16	Owned by private parties.
Steamer Stella	June 22	June 24	
Canal dump boat D	....do ...	....do ...	
Canal dump boat B	June 24	June 27	
Flat No. 93	June 27	.....	Still in dock.
Flat No. 116	June 29	.....	Do.
Steamer Lorna Doone	....do ...	June 29	Owned by private parties.
Dump boat No. 9	.....	.....	Under construction in dock.

Expenditures for operating and care of Des Moines Rapids Canal, etc.

Month.	Office and administration.				Canal and locks.			
	Salaries.	Supplies.	Miscellaneous.	Total.	Labor.	Supplies.	Current repairs.	Total.
1895.								
July	$375.00	$30.25	$6.20	$411.45	$1,745.00	$119.50	$341.93	$2,206.43
August	375.00	19.95	.....	394.95	1,785.00	145.29	468.01	2,398.30
September	375.00	.....	114.05	489.05	1,785.00	156.59	604.22	2,545.81
October	375.00	.....	.....	375.00	1,745.00	270.47	1,419.87	3,435.34
November	375.00	.....	.....	375.00	1,745.00	31.47	1,470.49	3,246.96
December	500.00	.....	56.20	556.20	1,292.50	87.69	673.21	2,053.40
1896.								
January	500.00	.....	.....	500.00	1,332.50	23.68	201.96	1,558.14
February	500.00	16.70	.....	516.70	1,287.50	38.09	244.89	1,570.48
March	500.00	.....	44.94	544.94	1,491.75	235.68	352.11	2,079.54
April	375.00	12.50	1.63	389.13	1,670.00	74.69	397.77	2,142.46
May	375.00	12.70	6.67	394.37	1,670.56	245.52	220.20	2,136.28
June	562.50	.....	93.75	656.25	1,587.50	79.10	29.02	1,695.62
Total	5,187.50	92.10	323.44	5,603.04	19,137.31	1,507.77	6,423.68	27,068.76

Expenditures for operating and care of Des Moines Rapids Canal, etc.—Continued.

Month.	Dredging canal.				Grand total.
	Labor.	Supplies.	Current repairs.	Total.	
1895.					
July					$2,617.88
August					2,793.25
September					3,034.86
October					3,810.34
November					3,621.96
December					2,609.60
1896.					
January					2,058.14
February	$187.00			$137.00	2,224.18
March					2,624.48
April		$128.64	$14.90	143.54	2,675.13
May	1,346.69	608.44	176.35	2,131.48	4,662.13
June	1,573.25	648.34	249.80	2,479.39	4,823.26
Total	3,056.94	1,385.42	441.05	4,883.41	37,555.21

Comparative expenditures for operating and care of Des Moines Rapids Canal for the fiscal years 1882–1896.

Year.	Office and administration.				Canals and locks.			
	Salaries.	Supplies.	Miscellaneous.	Total.	Labor.	Supplies.	Repairs.	Total.
1882	$3,710.00	$161.69	$550.62	$4,422.31	$21,122.70	$1,654.06	$1,946.03	$24,722.79
1883	4,821.12	289.86	449.52	5,560.50	25,813.40	2,216.87	3,203.01	31,233.28
1884	5,045.22	209.12	665.62	5,519.96	17,654.23	4,344.51	1,291.20	23,289.94
1885	5,015.00	245.31	573.88	5,834.19	17,615.97	1,995.92	5,237.88	24,849.77
1886	5,225.00	209.12	432.10	5,866.22	17,731.76	2,226.23	5,652.87	25,610.86
1887	4,375.00	85.19	424.48	4,884.67	18,326.23	2,752.80	3,775.59	24,854.62
1888	4,870.00	154.04	481.70	5,505.74	16,892.82	1,942.94	7,972.29	26,803.05
1889	3,750.00	26.80	318.82	4,095.62	17,241.79	2,277.97	3,689.20	23,208.96
1890	4,425.00	120.84	238.03	4,783.87	18,245.07	2,376.55	7,848.88	28,470.50
1891	5,175.00	162.76	113.38	5,451.14	18,785.73	2,725.27	11,863.31	33,374.31
1892	4,495.00	156.04	210.75	4,861.79	18,099.98	1,612.98	5,012.20	24,725.16
1893	5,720.00	137.13	138.73	5,995.86	17,464.67	2,162.64	6,822.35	26,449.66
1894	5,135.00	121.71	711.56	5,968.27	19,585.65	1,707.04	12,974.85	34,267.54
1895	5,083.00	156.38	314.92	5,554.63	19,264.68	2,004.19	7,712.16	28,981.03
1896	5,187.50	92.10	323.44	5,603.04	19,137.31	1,507.77	6,423.68	27,068.76

Year.	Dredging canal.					Miscellaneous.	Grand total.
	Labor.	Supplies.	Repairs.	Contract.	Total.		
1882	$2,340.43	$572.19	$846.58	$14,080.39	$17,839.49	$68.75	$47,053.34
1883	4,765.93	1,538.80	598.04	30,666.17	37,568.94	3,564.07	77,926.79
1884	7,485.45	4,789.32	1,262.02		13,536.79	536.73	43,283.42
1885	3,353.12	8,580.69	1,888.73		13,822.54		44,506.50
1886	4,984.55	3,017.49	3,530.41		11,532.45		43,009.53
1887	6,149.45	3,810.12	2,453.98		12,413.55		42,152.84
1888	5,084.77	2,267.62	1,808.85		9,161.24	1,372.32	42,802.35
1889	5,573.56	3,528.06	2,479.17		11,580.79		38,885.37
1890	3,196.58	1,260.78	6,284.07		10,741.43		43,995.80
1891	3,563.51	1,906.63	702.61		6,172.75		44,998.20
1892	11,333.23	6,370.52	4,259.47		21,963.22		51,550.17
1893	8,712.77	4,481.53	5,464.30		18,658.60		51,104.12
1894	6,719.81	2,227.41	7,716.02		16,663.24		56,899.05
1895	496.00	103.63	2,746.74		3,346.41		37,882.07
1896	3,056.94	1,385.42	441.05		4,883.41		37,555.21

Traffic statement of the Des Moines Rapids Canal for the fiscal year ending June 30, 1896.

Month.	Boats up.	Boats down.	Barges up and down.	Passengers.	Merchandise.	Grain.	Lumber.	Logs.	Shingles.	Laths.	Lockage at one lock.
1895.					*Tons.*	*Bush.*	*Feet.*	*Feet.*	*Number.*	*Number.*	
July	76	70	51	5,951	12,595	20,130	30,936,800	10,200,000	11,802,250	10,687	401
August	71	72	21	8,845	1,775	6,168	26,533,517	9,427,000	12,176,000	12,247,750	360
September	55	54	71	3,143	2,836	1,760	18,745,611	3,447,000	6,707,500	6,270,100	270
October	41	45	23	107	1,805	1,300	25,440,080	4,790,000	8,149,650	8,660,497	238
November	20	30	56	.....	1,540	.....	11,027,103	1,100,000	6,107,800	5,639,500	96
1896.											
March	6	7	2	41	60	210	.....	.....	.....	.....	15
April	30	25	17	277	1,664	715	2,060,000	1,860,000	960,000	750,000	119
May	72	23	47	2,375	14,923	9,010	2,131,000	.....	220,000	870,000	143
June	72	20	25	4,531	3,750	5,883	.....	.....	.....	.....	310
Total	443	346	313	25,270	40,948	45,176	116,874,111	30,824,000	46,122,200	34,448,534	1,952

Comparative traffic statement showing the total traffic that has passed through the canal since its opening in 1877, by fiscal years ending June 30.

Fiscal year.	Steamboats.	Barges.	Passengers.	Merchandise.	Grain.	Lumber.	Logs.	Laths.	Shingles.	Lockage at one lock.
				Tons.	*Bushels.*	*Feet.*	*Feet.*	*Number.*	*Number.*	
1878	670	548	.....	53,346	737,415	25,000,000	.....	4,000,000	3,700,000	824
1879	802	454	5,038	64,656	2,192,642	33,347,612	8,086,000	8,721,796	11,749,000	1,564
1880	967	651	13,231	78,989	2,197,469	21,832,478	13,160,960	27,863,640	30,651,000	2,497
1881	840	276	10,003	44,962	2,154,092	52,256,235	11,013,410	11,657,655	15,091,000	1,339
1882	760	444	8,588	29,043	781,817	17,150,011	4,475,000	3,112,825	4,885,250	2,292
1883	1,107	705	9,192	43,359	729,174	13,093,325	1,040,000	11,558,000	4,435,000	1,353
1884	913	245	13,057	54,215	470,580	57,018,151	9,399,764	15,924,645	25,182,250	1,908
1885	889	169	13,065	54,120	776,432	43,119,797	2,779,670	13,473,205	25,018,750	1,270
1886	784	218	22,221	56,001	465,681	22,769,823	3,195,360	4,302,800	8,253,000	755
1887	990	318	20,797	52,815	366,432	178,754,876	24,827,000	19,961,781	90,450,922	1,717
1888	595	233	8,330	33,160	143,037	166,827,752	34,505,000	83,642,450	49,848,840	1,749
1889	1,022	288	22,880	50,008	381,559	118,508,045	26,333,320	50,221,099	37,413,810	1,941
1890	924	477	14,529	71,453	397,788	146,078,329	26,689,300	44,316,167	73,540,370	1,827
1891	878	357	15,801	45,217	364,878	193,358,089	37,176,150	59,350,595	87,259,690	1,895
1892	577	191	10,260	12,228	63,210	140,654,084	24,514,000	39,476,926	61,141,137	1,233
1893	670	234	10,846	33,318	53,257	80,190,519	16,350,200	29,121,020	28,896,260	1,476
1894	619	312	14,752	43,182	83,650	117,360,783	8,612,000	54,710,727	42,112,415	1,394
1895	606	340	14,141	22,034	55,729	155,625,800	29,545,910	55,670,204	55,064,938	1,503
1896	789	313	25,270	40,948	45,176	116,874,111	30,824,000	46,122,200	34,448,534	1,952

Dates of opening and closing of canal for all years since its opening to navigation.

Year.	Canal opened.	Canal closed.	River opened.	River closed.	Highest water.		Lowest water.	
					Date.	Feet.	Date.	Feet.
1877	Aug. 22	Dec. 10	Feb. 17	Dec. 10	.....	20.55	Sept. —	0.65
1878	Mar. 8	Nov. 28	Open ...	Dec. 20	June 11	12.05	Sept. 22	1.45
1879	Mar. 17	Dec. 9	Mar. 6	Dec. 26	June 2	8.45	Oct. 4	1
1880	Mar. 8	Nov. 19	Jan. 5	Dec. 8	June 29	17.50	Aug. 24	2.05
1881	Apr. 16	Oct. 17	Mar. 25	No close	Oct. 29	18.95	Aug. 29	2.75
1882	May 6	Nov. 25	Open ...	Dec. 15	Apr. 25	15.90	Oct. 5	2.65
1883	Apr. 13	Dec. 6	Mar. 1	Dec. 27	May 8	15.45	Sept. 22	2.10
1884	Apr. 1	Nov. 23	Mar. 15	Dec. 30	Mar. 13	16.80	Aug. 25	2.80
1885	....do ...	Nov. 24	Mar. 14	Dec. 14	Mar. 15	12.80	Nov. 30	3.40
1886	....do ...	Nov. 21	Mar. 15	Dec. 2	May 6	15.95	Dec. 1	.50
1887	Mar. 28	Nov. 23	Feb. 11	Dec. 21	Feb. 12	11.60	Nov. 28	0
1888	Mar. 29	Nov. 22	Mar. 1	No close	May 16	19.65	Dec. 26	— .80
1889	Mar. 18	Nov. 23	Mar. 3	Feb. 24	Feb. 26	10.75	Dec. 5	— .70
1890	Apr. 1	Nov. 20	Jan. 28	Jan. 21	June 30	12.60	Jan. 3	—2.40
1891	....do ...	Nov. 21	Open ...	No close	Mar. 29	10.80	Nov. 30	—1.60
1892	....do ...	Nov. 23	Feb. 2	Dec. 23	June 30	19.25	Dec. 18	— .80
1893	....do ...	Nov. 15	Mar. 10	Dec. 4	May 15	14.85	Nov. 20	— .90
1894	Mar. 21	....do ...	Mar. 1	Dec. 30	June 3	11.35	Dec. 4	— .90
1895	Mar. 15	Nov. 23	Feb. 26	Dec. 5	Mar. 4	5.10	Dec. 3	—1.40
1896	Apr. 1	.....	Mar. 3	.....	.....	.....	.....	.....

REPORT OF MR. M. MEIGS, UNITED STATES CIVIL ENGINEER.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, July 1, 1896.

COLONEL: I have the honor to submit the following report on "Operating and care of Des Moines Rapids Canal" for the fiscal year ending June 30, 1896:

The canal was closed November 22, 1895, and opened April 1, 1896, when a full force was put on. It was opened for navigation two hundred and seventy-two days and closed ninety-four days (between March 1 and April 1 the canal was open to such boats as came along, the locks being operated by hand and in the daytime only). During the past spring and early summer a normal spring rise has occurred and navigation has been good, a large part of the downstream traffic going outside the canal, notably all rafts, except one, which lay in the canal all winter. The highest stage attained during the navigable season of the year was 11.9 feet on the Lower Lock gauge, June 2 and 3, 1896, and the lowest was 0.4 feet, on September 25 to 29, 1895. The low water during the fall and summer of 1895 was very detrimental to navigation and many boats, especially the packets, were laid up early. The business depression of the country, which shows little improvement from last year, combined with the low water, has greatly affected the canal traffic, as will be seen by the comparative exhibit herewith.

Repairs to gates, machinery, and buildings.—On November 23, 1895, the water was drawn off from the canal and the usual examination made. At the Lower Lock the masonry about the lower culvert gates continues to deteriorate, and where the face of the stone had spalled off it was replaced where necessary with oak plank bolted to the wall. The operating of the upper and lower culvert gates has been interfered with from time to time by stone spalling off the face of the masonry and lodging between the gates and the wall, causing in some cases the breaking of the gate and the expense of renewing the same. By means of a shutter and a temporary bulkhead two gates at the lower end of the lock and one at the upper end were repaired in December, 1895. New frames were cast and fitted to the openings in each. This work was done with the help of a diver and in very cold and inclement weather. In May two leaks developed in the pipes supplying the cylinders on the east side of the Guard Lock and were repaired with clamps by a diver. The pipes supplying the hydraulic machinery of the locks have now been under ground for nearly twenty years and their life is about gone. The defects that develop show the greater part of the pipe to be still sound, but here and there deep pitting has occurred, which is liable to give way at any time and anywhere. It is probable that one or two seasons' use can be had of these pipes, when they will have to be abandoned and new pipes laid. The three boilers in use at the locks have also been in use twenty years, and should in the near future have new fire boxes and new tubes. They are of the pepper-box type, and in rebuilding them they should be made 18 inches longer and have a submerged upper flue sheet and tubes, as frequent trouble occurs from overheated and leaky flues now, the upper ends of the flues being exposed to the flames without any water on the outside of them. It will not be a great expense to alter them in the manner proposed. The upper gates at the Lower Lock will need to have the upper arms replaced and to have new sheathing, which has become very rotten. The lower gates were repaired in December, 1895, with new sheathing plank, the old plank being completely rotten.

Machine shop at lower lock.—At the machine shop the lock engineers were kept busy during the winter months reseating valves and repairing and renewing worn-out parts of the canal machinery. A large amount of work was done to the machinery of the dredge *Phœnix*, which was in the dry dock for rebuilding. Headlights were replated for the *Vixen*, *Coal*, *Bluff*, *Parke*, *Alert*, *Lucia*, and *Ada*, a small dynamo having been altered for the purpose. The engines of the canal launch *Lucia* and all her machinery were overhauled, as well as her boiler.

Dredging canal.—On May 1 the dredge *Phœnix* was put at work removing the deposit of two years from the canal, the low water of the past two seasons making it impracticable to do any dredging on account of the danger of navigating the rapids with dump boats at low water. The extreme dryness of the last two seasons, however, prevented any great deposit in the canal, so that navigation was not interfered with by lack of dredging. Work was begun on May 1 with a single crew, and on the 14th a double crew was put on, which worked uninterruptedly until June 30. Dredge *Phœnix* and towboat *Vixen* were employed on the work. As usual the work of the night force invariably exceeded that done by the day force, which shows clearly the advisability of working the plant in this manner. The two new dump boats have about 6 cubic yards' greater capacity each than the old ones, and have

proved an advance on the old plan in many ways. The following summary shows the dredging performed:

Above Guard Lock	cubic yards	4,555.1
Below Guard Lock	do	6,617.6
Mouth of Ballingers Creek	do	4,901.2
Mouth of Lamallees Creek	do	15,436.6
Mouth of Prices Creek	do	14,229.4
Below Middle Lock	do	2,172.9
Below Lower Lock	do	215.4
Total	do	48,128.2

During September, 1895, a small derrick boat was used to remove a few scattered rocks from the channel below the Lower Lock, and in April, 1896, the dredge *Phœnix* and launch *Lucia* were employed three days below the bridge in the same work.

Operating dry dock.—The dry dock has been in constant use the past year. Quite a number of private boats made use of it for greater or less repairs. Several new boats were built complete and others rebuilt. The canal dumps were repaired and a new hull was built for the canal launch *Lucia*. The following partial list shows work accomplished:

Built.—Two dump boats (20 by 73 feet), 1 coal flat (No. 63, built of material on hand), 2 towboats (75 by 17 feet), one of which was for the Hennepin Canal improvement and one for a dredge tender on the Mississippi River improvement.

Rebuilt.—One dredge, 1 launch.

Commenced.—Two dump boats (Nos. 9 and 10).

Repaired.—Eleven barges, 11 dump boats, 18 steamboats, 2 pile drivers, 1 grasshopper.

Broken up.—Four dump boats (Nos. 1, 2, 4, and 6).

Included in the above list are 9 private steamboats and 1 barge, which paid total dockage fees to the amount of $568.75. Of this amount $212.50, due from the steamer *Pittsburg*, was collected by the Rock Island office.

During the past year I have been assisted by Mr. John R. Carpenter, acting superintendent; Mr. O. S. Willey, clerk, and Mr. W. F. Grady, stenographer and storekeeper, who have performed their duties well and faithfully.

Very respectfully, your obedient servant,

M. MEIGS,
United States Civil Engineer.

Lieut. Col. W. R. KING,
Corps of Engineers, U. S. A.

X 4.

OPERATING AND CARE OF GALENA RIVER IMPROVEMENT, ILLINOIS.

During the past year the lock was open for navigation from July 1 to November 21, 1895, and from April 4 to June 30, 1896, a period of 232 days, during which time there passed through 234 steamboats and barges, carrying 788 passengers and 812 tons of merchandise. There also passed through the lock 1,339,000 feet, B. M., lumber, 665,000 shingles, and 974,000 laths. One hundred and forty-five lockages were made.

The expenses of the fiscal year ending June 30, 1896, were $3,400, the same being provided for under section 4 of act of July 5, 1884, for "Operating and care of canals and other works of navigation."

Abstract of appropriations.

By act approved—	
September 19, 1890	$100,000.00
July 5, 1884, for fiscal year ending—	
June 30, 1894	1,500.00
June 30, 1895	5,135.68
June 30, 1896	3,400.00
Total	110,035.68

Money statement.

June 30, 1896, amount drawn from Treasury under indefinite appropriation during fiscal year	$3,400.00
June 30, 1896, amount expended during fiscal year	3,400.00

Expenditures for operating and care of Galena River improvement for fiscal year ending June 30, 1896.

Month.	Superintendence and office expenses.	Operating.		Repairs to lock.	Total.
		Labor.	Supplies.		
1895.					
July	.....	$170.00	.....	.....	$170.00
August	.....	170.00	$14.87	.....	184.87
September	.....	170.00	.....	.....	170.00
October	.....	170.00	.....	.....	170.00
November	.....	170.00	.....	.....	170.00
December	.....	170.00	18.75	$734.88	923.63
1896.					
January	$19.61	170.00	.....	180.92	370.53
February	200.00	170.00	.....	.....	370.00
March	.....	170.00	.....	.....	170.00
April	.....	170.00	.....	69.16	239.16
May	.....	170.00	.....	.....	170.00
June	14.06	170.00	.....	107.75	291.81
Total	233.67	2,040.00	33.62	1,092.71	3,400.00

Comparative statement of expenditures for operating and care of Galena River improvement for the fiscal years 1894–1896.

Year.	Superintendence and office expenses.	Operating.		Repairs to lock.	Dredging.	Total.
		Labor.	Supplies.			
1894	$7.17	$510.00	$4.84	$113.67	.....	$635.68
1895	121.16	2,143.50	43.63	2,791.71	$900.00	6,000.00
1896	233.67	2,040.00	33.62	1,092.71	.....	3,400.00

Traffic statement of the Galena River improvement for the fiscal year ending June 30, 1896.

Month.	Boats up and down.	Passengers.	Merchandise.	Lumber.	Shingles.	Laths.	Lockages.
1895.			*Tons.*	*Feet.*	*Number.*	*Number.*	
July	61	125	228	.....	.....	.....	38
August	33	71	14	900,000	530,000	800,000	30
September	21	86	3	200,000	70,000	50,000	18
October	16	24	9	195,000	65,000	124,000	11
November	14	5	34	.....	.....	.....	6
1896.							
April	29	167	308	1,000	.....	.....	31
May	31	304	152	.....	.....	.....	.....
June	29	6	64	43,000	.....	.....	11
Total	234	788	812	1,339,000	665,000	974,000	145

Comparative traffic statement showing total traffic that has passed through Galena River lock, and the dates of opening and closing to navigation for the fiscal years 1894–1896.

Year.	Steamboats and barges.	Passengers.	Merchandise.	Lumber.	Shingles.	Laths.	Lockages.	River opened.	River closed.
			Tons.	*Feet.*	*Number.*	*Number.*			
1894	167	1,426	1,228	.....	.....	.....	.....	Mar. 12	Nov. 10
1895	471	4,798	1,939	.....	.....	.....	320	Mar. 26	Nov. 21
1896	234	788	812	1,339,000	665,000	974,000	145	Apr. 4	.....

X 5.

MISSISSIPPI RIVER BETWEEN ST. PAUL AND MINNEAPOLIS—CONSTRUCTION OF LOCK AND DAM NO. 2.

During the year, the money available being insufficient to build the lock foundation, no construction work was performed. Some additional examinations and borings were made and a part of the needed lands and flowage rights were secured. The act of June 3, 1896, appropriated $100,000 for this work, and there is now sufficient money available to build the lock foundation and a portion of the side walls.

Abstract of appropriations.

By act approved—	
August 17, 1894	$51,000.00
July 13, 1892 (allotted by act of August 17, 1894)	49,877.67
By act of June 3, 1896	100,000.00
	200,877.67

Money statement.

July 1, 1895, balance unexpended	*$98,372.73
Amount appropriated by act of June 3, 1896	100,000.00
	198,372.73
June 30, 1896, amount expended during fiscal year	9,051.56
July 1, 1896, balance unexpended	189,321.17
Amount (estimated) required for completion of existing project	497,357.33
Amount that can be profitably expended in fiscal year ending June 30, 1898	497,357.33
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

* The amount reported in the Annual Report for 1895 was erroneous, and should have been $98,372.73.

APPENDIX Y.

CONSTRUCTION OF RESERVOIRS AT HEAD WATERS OF MISSISSIPPI RIVER; IMPROVEMENT OF RIVERS IN WISCONSIN AND MINNESOTA TRIBUTARY TO MISSISSIPPI RIVER, AND OF RED RIVER OF THE NORTH, MINNESOTA AND NORTH DAKOTA; GAUGING MISSISSIPPI RIVER AT ST. PAUL.

REPORT OF LIEUT. COL. W. A. JONES, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Construction of reservoirs at head waters of Mississippi River.
2. Operating and care of reservoirs at head waters of Mississippi River.
3. Chippewa River, including Yellow Banks, Wisconsin.
4. St. Croix River, Wisconsin and Minnesota.
5. Minnesota River, Minnesota.
6. Red River of the North, Minnesota and North Dakota.
7. Gauging Mississippi River at or near St. Paul, Minnesota.
8. Surveys for reservoirs at sources of Mississippi, St. Croix, Chippewa, and Wisconsin rivers.

SURVEY.

9. Chippewa River, Wisconsin.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., July 18, 1896.

GENERAL: I have the honor to transmit herewith reports upon the works for improvement of rivers in my charge for the fiscal year ending June 30, 1896.

Very respectfully, your obedient servant,

W. A. JONES,
Lieut. Col., Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

Y 1.

CONSTRUCTION OF RESERVOIRS AT HEAD WATERS OF MISSISSIPPI RIVER.

The reservoir project is the outcome of surveys and examinations in 1869, 1874, 1878, and 1879, the results of which are published in appendixes to various annual reports of the Chief of Engineers. The résumé of the subject is given in the report of the Board of Engineers, printed in Appendix A A to the Annual Report of the Chief of Engineers for 1887.

From the results of the surveys and examinations just noted, and further examinations in 1880, the first cost of constructing forty-one reservoir dams in Minnesota and Wisconsin was placed at $1,809,083.50, exclusive of that of land damages, which could not be given in advance. (See p. 1781, Appendix W to the Report of the Chief of Engineers for 1881.)

The project for this improvement was inaugurated in 1880 by an appropriation for the construction of a reservoir dam at Lake Winnibigoshish, made by act of Congress approved June 14, that year. For the reasons given in the Annual Report for 1886 the work of construction was commenced and has been continued in Minnesota.

The project has for its object the construction and maintenance of reservoirs at the head waters of the Mississippi River, in the State of Minnesota, for the purpose of collecting the surplus water, principally from the precipitation of winter, spring, and early summer, to be systematically released so as to benefit navigation upon the Mississippi River below the dams and as far down as Lake Pepin. Reduction of heights of floods in localities immediately below the dams is expected to obtain to some extent, but control of extended floods or freshets is not expected.

There are five completed reservoirs, viz:

At Lake Winnibigoshish, completed in 1883–84; capacity, 45,800,000, 000 cubic feet.

At Leech Lake, completed in 1884; capacity, 30,000,000,000 cubic feet.

At Pokegama Falls, completed in 1884; lift of dam increased in 1889; capacity, 4,700,000,000 cubic feet.

At Pine River, completed in 1886; capacity, 7,500,000,000 cubic feet.

At Sandy Lake, completed in 1895; capacity, 3,000,000,000 cubic feet.

The following rules and regulations have been adopted to control the use and administration of the reservoirs:

1. Penalties.—The river and harbor act of Congress of August 11, 1888, contains the following in relation to the reservoirs at the head waters of the Mississippi River: "And it shall be the duty of the Secretary of War to prescribe such rules and regulations in respect to the use and administration of said reservoirs as, in his judgment, the public interest and necessity may require; which rules and regulations shall be posted in some conspicuous place or places for the information of the public. And any person knowingly and willfully violating such rules and regulations shall be liable to a fine not exceeding five hundred dollars, or imprisonment not exceeding six months, the same to be enforced by prosecution in any district court of the United States within whose territorial jurisdiction such offense may have been committed."

2. Authority of officer in charge of the reservoirs.—The accumulation of water in, and discharge of water from, the reservoirs, including that from one reservoir to another, shall be under the direction of the officer in charge of the reservoirs and of his authorized agents, subject to the following restrictions and considerations:

a. The surplus over the ordinary low-water supply to the reservoirs and so much of said low-water volume as may not be immediately needed for any purpose below any dam, shall be stored until the limit of capacity or safety of the reservoirs is reached, or until water is needed for navigation upon the streams below the dams.

b. During the season of navigation on the upper Mississippi River the volume of water discharged from the reservoirs shall be so regulated by the officer in charge as to maintain as nearly as practicable, until navigation closes, a uniform and sufficient stage of water in the navigable reaches of the Upper Mississippi and in those of any tributary thereto that may be navigated and on which a reservoir is located. The discharge may, however, at any time, be increased or diminished in order to admit of inspecting or repairing the dikes, dams, and their appurtenances.

c. Floating bodies, other than logs, may be sluiced through the reservoir dams, if their passage be deemed proper or necessary by the officer in charge. Logs may be sluiced through the said dams under the following conditions, viz:

They must be in drives of not less than 3,000,000 feet, board measure, and must be in compact shape for being rapidly sluiced so as to avoid unnecessary loss of water; and the parties having them in charge must employ a sufficient force of men to keep the sluices running full of logs, and to prevent the formation of log-jams as far above and below the dams as may be designated by the officer in charge or his authorized agents. Drives of less than 3,000,000 feet, board measure, may be sluiced

through the dams under the same conditions and requirements when the quantity is either a remnant or the total of a drive; provided, however, that there be no other drive likely to join it within forty-eight hours to make up 3,000,000 feet or more.

When all the logs that are destined to the same boom are sluiced through a reservoir dam located on a tributary of the Mississippi River, and it not being necessary, at the time of such sluicing, to draw from the reservoir for purposes of navigation, sufficient water may be liberated to allow of the rear being taken off once, so that the logs may reach the Mississippi River. If, however, a drive be delayed in reaching a reservoir dam, and through no fault or incompetency of the parties in charge of it, and, in the opinion of the officer in charge, it will not arrive before a regular period of discharge of water from the reservoir, the rear of the logs already through the dam may be taken off as before said; the rear of the delayed drive must then wait until the reservoir water is liberated for purposes of navigation.

d. Obstructions to flow of water: No person shall drive logs into a stream or pond above or below a reservoir dam when, in the opinion of the officer in charge, such act would prevent the necessary flow of water to or from such dam, or in any way injure the dam and its appurtenances, its dikes, and embankments; and should logs lying above or below a dam constitute at any time an obstruction or menace as beforesaid, the owners of said logs will be required to immediately remove them.

3. Handling gates.—No one, unless so authorized by the officer in charge, shall open or close any gate pertaining to the said reservoir dams, or in any way interfere with the watchmen or other Government employees at the reservoirs in the discharge of their duties. The watchmen or other employees at the dams may call for assistance from those in charge of a drive of logs when gates are to be opened, closed, or maneuvered in connection with the work of sluicing said drive.

4. No one shall trespass on any reservoir dam, dike, embankment, or upon any property pertaining thereto.

Approved:

WM. C. ENDICOTT,
Secretary of War.

WAR DEPARTMENT, *February 21, 1889.*

Gaugings of the Mississippi River at St. Paul. to determine the effects of reservoir water, have been made to a limited extent during the past six years. They form the subject of a separate report.

Since February 1, 1895, the expense of the care and maintenance of the completed reservoirs has been paid out of the appropriation for "operating and care of canals and other works of navigation, indefinite," and forms the subject of a separate report, which is referred to for a statement of the effect during the seasons of 1893, 1894, and 1895, of the reservoir water upon the Mississippi River at St. Paul.

Amount expended to June 30, 1895, including outstanding liabilities, $809,492.52.

OPERATIONS DURING THE PAST FISCAL YEAR.

Sandy Lake Dam.—This dam was completed in October, 1895. The cost was $113,976.26. The dam is a timber structure filled with rock. It withstands an extreme head of 10.9 feet. The openings are: Five small sluices 5 feet by 4 feet controlled by sliding gates; one log sluice 11 feet wide controlled by an improved bear-trap gate, supplemented by stop plank for use in case of accident to the bear trap; a navigable pass or lock 40 feet wide having instead of the ordinary lock gate two improved bear-trap gates. All the openings are available for the release of water. A detailed description of the dam is given in the report of Mr. Archibald Johnson, assistant engineer, appended hereto.

Pokegama Falls Dam.—An application has been made to the United States district court for the condemnation of 4.71 acres of land at both ends of the dam. This action was deemed necessary in order that the title to the ground upon which the dam rests and upon which new watchmen's quarters are to be built should rest solely in the United States.

The following survey notes taken by Archibald Johnson, assistant engineer, May 20, 1896, when 2,500 cubic feet per second were being

released from the Pokegama Falls Dam, are inserted in this report, in order to preserve for future reference a record of the slope of the water surface in the Mississippi River for a distance of 1,225 feet below the dam:

Station 0 = Elevation 1,278.773 feet immediately above dam.
Elevation 1,269.643 feet immediately below dam.
Station 2 + 80 = Elevation 1,268.897 feet.
Station 3 + 75 = Elevation 1,267.308 feet crest of falls.
Station 4 + 80 = Elevation 1,258.325 feet foot of falls.
Station 8 + 50 = Elevation 1,255.220 feet.
Station 12 + 25 = Elevation 1,254.636 feet foot of rapids.

The stations are 100 feet apart and the line was run along the left (or east) side of the river.

Gull Lake Dam.—Some years ago a logging corporation built a cheap dam at the site of the proposed Gull Lake Reservoir Dam. The land was afterwards homesteaded by a second party, contested by a third party, and eventually reverted back to the United States. July 30, 1895, the tract upon which the dam is located was permanently reserved for reservoir purposes by order of the President, thus giving to the Government the ownership of the present dam. The corporation that built the structure was agreeable to this arrangement. As soon as the balance of flowage rights are acquired and ditches excavated between Gull and Round lakes and Round and Long lakes, title to the temporary dam will make a small-sized reservoir available for a year or two, at the end of which time an appropriation should be made to replace the present with a substantial structure.

GENERAL.

A map is submitted showing location of reservoirs constructed and possible sites that may be made available in Minnesota at the head waters of the Mississippi River and the Red River of the North.

Amount expended during the fiscal year ending June 30, 1896, including outstanding liabilities, $10,819.07.

For commerce benefited by the reservoirs reference must be made to the commercial statistics of the Mississippi River.

Abstract of appropriations

By act—		By act—	
Approved June 14, 1880	$75,000	Approved September 19, 1890	$80,000
Approved March 3, 1881	150,000	Approved July 13, 1892	60,000
Passed August 2, 1882	300,000	Of August 17, 1894	51,000
Approved July 5, 1884	60,000	Passed June 3, 1896	80,000
Approved August 5, 1886	37,500		
Of August 11, 1888	12,000	Total	905,500

Money statement.

July 1, 1895, balance unexpended	$18,373.61
Amount appropriated by act of June 3, 1896	80,000.00
	98,373.61
June 30, 1896, amount expended during fiscal year	12,998.64
July 1, 1896, balance unexpended	85,374.97
July 1, 1896, outstanding liabilities	186.56
July 1, 1896, balance available	85,188.41
Amount (estimated) required for completion of existing project	903,583.50
Amount that can be profitably expended in fiscal year ending June 30, 1898	150,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

REPORT OF MR. ARCHIBALD JOHNSON, ASSISTANT ENGINEER.

ST. PAUL, MINN., *January 28, 1896.*

COLONEL: I have the honor to submit the following report on the construction and cost of Sandy Lake Dam:

The dam is built for a flowage line at an elevation of 1,220 feet above sea level. The elevation of the lowest known water in the lake is 1,210.6 feet; hence the extreme head above low water is 9.4 feet.

It has an open log sluice 11 feet wide, controlled by an improved bear-trap gate. There are also five small sluices each 5 feet wide and 4 feet high, controlled by sliding gates. In addition to this there is a navigable pass controlled by two improved bear-trap gates 160 feet apart. All gates are so constructed that they will act under a reversed head, it being necessary at times when Sandy Lake is low in the fall to keep the reservoir water out, so as to get the full benefit of it along the Mississippi River.

The dam is built of crib work filled with rock, and rests on a pile foundation. It is built across Sandy River on lots numbered 11 and 14 of section numbered 25 of township numbered 50 north, of range numbered 24 west of fourth principal meridian. There is also a dike about 650 feet long in lot numbered 1 of the same section, township, and range. By river the dam is about three-fourths of a mile from Sandy Lake, and 1¼ miles from the Mississippi River. It is about 54 miles by river, and 35 miles by wagon road from Aitkin, and about 14 miles from McGregor by a winter road.

The country around Sandy Lake is heavily timbered, and thus far sparsely settled. The only supplies purchased in the region were wood, round piles, vegetables, and hay.

The most of the lumber was purchased at Aitkin and Cloquet, but some was purchased in Minneapolis. Groceries, feed, and oats were purchased at Aitkin. The rest of the supplies and materials were purchased in St. Paul, Minneapolis, and Duluth. The bulk of the lumber and supplies were delivered by steamboats plying between Aitkin and Grand Rapids. The freight rates were usually 20 cents per 100 pounds and $3 per thousand for lumber. In 1895 50 cents per 100 pounds was paid for all freight, but the amount received was not large. Considerable lumber from Cloquet was shipped by rail to La Prairie and then floated down to the dam. The cost of this was about $1.50 per thousand.

The work was commenced on July 5, 1891, and completed on October 28, 1895. The work, however, was not continuously prosecuted, owing sometimes to the impracticability of carrying on work in cold weather, delays in changing plans, but sometimes for want of appropriations. It was suspended on December 9, 1892, resumed on May 13, 1893, suspended February 7, 1894, resumed September 6, 1894, suspended December 31, 1894, again resumed April 22, 1895, and completed on October 28, 1895.

Originally the dam was designed and approved for a log sluice 11 feet wide and controlled by an improved bear trap, and in addition 12 sluices, each 5 feet wide and 4 feet high. The river and harbor act of Congress approved July 13, 1892, appropriated "for care and maintenance of reservoirs at the headwaters of the Mississippi River, $60,000, of which $30,000 may be expended for the construction of a navigable pass through Sandy Lake Dam." This necessitated new designs for the dam. A general plan was submitted to the Chief of Engineers August 8, 1892, for approval. The design was referred by the Chief of Engineers, September 26, 1892, to a board of engineers, consisting of Maj. Amos Stickney, Maj. Alex. Mackenzie, and Capt. W. L. Marshall. The board called for detailed drawings and a working model. These were made and transmitted to the Board April 6, 1893. The plans were approved by the Chief of Engineers June 30, 1893.

The river at the dam site is about 125 feet wide and the formation consists mostly of sand, some gravel, and pockets of blue clay. There were also found in the foundation, at a depth of about 10 feet, a good many specimens of lignite coal.

MACHINERY AND TOOLS.

The most of the machinery and tools were brought from Pine River Dam, which reduced the cost of the work very materially. A good many tools, however, were purchased to replace those worn out.

BUILDINGS CONSTRUCTED.

The construction of the necessary buildings required during construction and after the completion of the dam was commenced in July, 1891, and completed in the spring of 1892. The following is a list of the buildings:

1 laborers' quarters	feet..	20 by 48
1 dining room and kitchen	do...	20 by 44
1 warehouse	do...	20 by 36
1 carpenter shop	do...	20 by 36
1 blacksmith shop	do...	18 by 30
1 tool house	do...	14 by 32
1 stable with five double and two single stalls	do...	30 by 32

One house for watchmen's quarters, a plan of which is shown on page 1697, Annual Report of Chief of Engineers for 1894.

All the buildings are one-story frame, with shingled roofs. With the exception of the watchmen's quarters, they are finished with rough boards of inch lumber and felt paper. The watchmen's quarters are finished with planed lumber and plastered. It rests on oak blocks. The cellar is lined with 6 by 12 inch pine timber.

COFFERDAM.

It was commenced on July 31, 1891, and completed November 16, 1892. It was comprised of two rows of round piles, 12 feet from center to center, with the exception of 62 feet of the east end of the upper part, where the rows were 14 feet apart. The piles in each row were 8½ feet from center to center, cut off at an elevation of 1,217 feet above sea level, or about 8 feet above the ground, and capped with 12 by 12 inch timber. With the exception of two places where the water was deep, the inside sheeting was 4 by 12 inches by 16 feet and the outside 6 by 12 inches by 16 feet. In the deep places mentioned, 6 by 12 inches by 20 feet and 6 by 12 inches by 24 feet was used. The sheeting was cut off at an elevation of 1,218 feet above sea level, 2 feet below the flowage line, or about 9 feet above the ground. Inch rods of round iron 8½ feet apart were passed through the caps, to prevent the filling from spreading the sheeting. In May, 1892, when a flood occurred, the outside of the cofferdam was raised 3 feet by driving 3-inch plank along the inside of the outer row of sheeting and backing it with earth. On top of the outer row of sheeting and in contact with the 3-inch plank was placed concrete 4 inches square in section, to cut

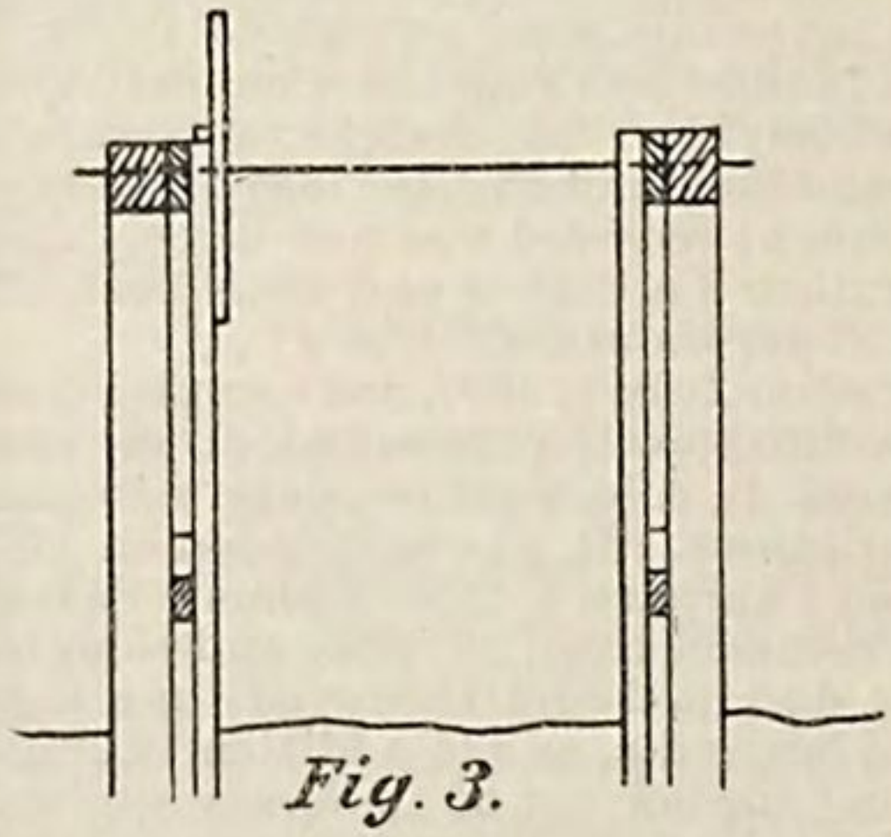


Fig. 3.

off leakage between the plank. The above description applies to the construction of the cofferdam on the bed of the river. After the first portion of the dam was completed it was necessary to construct a part of the second cofferdam on the floor of the completed portion of the dam. Fig. No. 1 * shows a section and Fig. No. 2 * a side view of the cofferdam.

The total length of cofferdam built was 829 feet, of which 742 linear feet was like that shown in Figs. Nos. 3 and 4,* and 87 feet like that shown in Figs. Nos. 1 and 2. These measurements are along the center lines.

After the dam was completed the earth in the cofferdam was removed and placed behind the north pier. All the sheeting and the round piles at the upper and lower ends were pulled out, but the round piles on the side were cut at low water. The lumber taken out was used in completing the top of the piers of the navigable pass.

EXCAVATION OF FOUNDATION.

After the cofferdam for the south half was completed and the water pumped out the work of excavation was commenced. The water was pumped out on September 28, 1891, and excavation was commenced the following day. The pumping was done with a 10-inch Heald and Sisco pump driven by a 25 horsepower boiler and engine. The water in the second cofferdam was pumped out on November 14, 1892, and two days after excavation was commenced, and completed July 17, 1893.

The excavation in the south half of the dam was carried down to a plane 1,206.75 feet above sea level, or about 2¾ feet below the bed of the river, excepting in the recess under the log sluice gate, where it was 3 feet lower. In the north half or under the navigable pass it was 1 foot deeper. The material was removed by means of cars

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*Not printed.

and a hoisting engine and deposited in dumps. It was afterwards used in filling between and under caps and behind piers.

The amount of material excavated was 5,926 cubic yards.

ROUND PILES IN DAM.

The driving was commenced on November 12, 1891, and completed on August 21, 1893.

The material in the foundation is sand, except in the lower and right-hand corner, where there is considerable blue clay overlying sand. The sand in the foundation is not as compact as it is usually formed in the beds of streams. In the south half of the dam the surface settled from 4 to 6 inches during the driving. As the surface was settling the penetration of the piles became less for each blow. In the north half, in which is the navigable pass, there was some settlement, but it was not as noticeable as in the south half. It had probably settled from the jarring of the hammers while the first half was being driven. The penetration of the piles is also greater than it is usually in sand foundations in the beds of streams. The piles were all of Norway pine and well seasoned.

Two Mundy steam-hoisting engines were used in driving, one a single and the other a double cylinder engine. In operating the hammer, an inch and a half manila rope was tied to the bolt connecting the lugs of the hammer, then passed over the top sheave of the leaders, and the next around the drum of the engine. When the friction is released the hammer falls and pulls the rope with it and unwinds from the drum. The blow, however, is not as effective as if the hammer was dropped from nippers, but the blows are more rapid, and this in a measure compensates for the diminished force of the hammer by keeping the material around the piles looser than it would be in the case of using nippers. Rings of $\frac{5}{8}$ by $2\frac{1}{2}$ inches Norway iron were used to protect the head of the pile.

The number of round piles driven in the foundation was 1,605.

The greatest load on any bearing pile is about $3\frac{1}{2}$ tons.

SHEET PILING.

The driving of sheet piles was commenced November 14, 1891, and completed October 15, 1893.

There is a line of sheeting extending all around the foundation, lines around depressions above gates, two lines forming diaphragms into the banks, a line extending about 30 feet below the recess of the upper gate and on the south side, two lines of 3-inch sheeting 6 inches apart under the floor of the first half of the dam; also lines immediately below the recesses of the gates in the navigable pass, which are not tongued or grooved, but simply driven close together. The driven end is cut with a bevel of 2 inches in 12 inches. These lines of sheeting are of 6 by 12 inches by 16 feet, 5 by 12 inches by 16 feet, 4 by 12 inches by 12 feet, and 3 by 12 inches by 8 feet in dimension. The 16-foot lengths were driven from 10 to 12 feet, the 12-foot lengths from 8 to 10 feet, and the 8-foot lengths about 6 feet in the ground.

At a distance of $18\frac{1}{2}$ feet from the upper end of the dam a line of triple-lap sheeting extends across the foundation and forms the upper sides of the recesses underneath the log sluice and upper navigable pass gates. It is also continuous around the recesses underneath the log sluice and the two pass gates.

These sheet piles were made by fastening together three 2 by 12 inch by 16-foot oak plank, allowing the middle to project out 2 inches, thus forming a tongue on one side and a groove on the other. They were fastened together by means of half-inch screw bolts and half-inch boat spikes. Two screw bolts were put near the ends and then one every two feet, alternating from side to side. The boat spikes were placed opposite the screw bolts. They were driven by the pile driver, aided by a jet of water from a steam force pump. In driving the 4-inch and 6-inch sheet piles a cast-iron cap or follower was used which fitted over the head of the pile 6 inches. In the top of the follower is fitted a wooden block of some close-grained wood, 7 inches long and 12 inches in diameter, which receives the blows of the hammer. This saves the head of the pile from being battered or splintered, and it can be driven to a greater depth than it could be without it.

In first using the jet on the triple-lap sheet piles, a groove was made in the inner plank to receive a half-inch gas pipe of the length of the pile which was connected with the force pump by means of a heavy $1\frac{1}{2}$-inch water hose. The aperture at the lower end of the gas pipe was reduced to a diameter of about three-eighths of an inch. The water was then forced to the bottom of the pile and the sand loosened. This worked well until the sheet pile struck gravel, when the nozzle of the pipe would become battered or filled with gravel. The pressure in the hose would then burst a coupling somewhere. Another source of trouble was the frequent breakages

in the connection between the pipe and the hose on account of the jarring of the hammer. This method of applying the jet after a while was abandoned, and the nozzle of the pipe was thrust by hand under the point of the pile, and the result was more satisfactory. The piles are driven into the ground from 12 to 14 feet.

The number of triple-lap sheet piles driven is 563 = 54,048 feet, B. M.

The amount of pine sheeting put in place is as follows:

	Feet, B. M.
813 pieces 6 by 12 inches by 16 feet	78,048
28 pieces 5 by 12 inches by 16 feet	2,240
352 pieces 4 by 12 inches by 12 feet	16,896
326 pieces 3 by 12 inches by 8 feet	7,824
Total	105,008

FILLING BETWEEN AND UNDER CAPS AND BEHIND PIERS.

This was commenced on May 9, 1892, and completed October 19, 1895.

The space behind the piers and between and under caps was filled with earth, excepting as hereinafter noted, where concrete was used.

The amount of earth filling is 7,406 cubic yards.

CONCRETE.

The spaces between and under the caps in the depressions underneath the log-sluice and navigable pass gates were filled with concrete. For a distance of 20 feet below the hinges of the lower leaves, and for the same distance above the hinges of the upper leaves, concrete to the depth of 6 inches was put in, excepting a space of about 4 feet next to the hinges, where it was about 18 inches deep.

The concrete was made of 1 part Louisville cement, 2 parts clean, sharp sand, and 4 parts fine gravel.

The amount of concrete put in place is 132 cubic yards.

CAPS IN FOUNDATION.

The caps underlying piers are of 12 by 12 inch timbers drift-bolted on the heads of the piles with 1 by 20 inch bolts of round iron. Elsewhere they consist of two 6 by 12 inch pieces screw bolted to a 6-inch tenon 12 inches long cut in the end of the pile with two 1 or $\frac{7}{8}$ inch bolts. At the anchorages the tenons are dovetail in form, being 5 inches thick at the neck and 7 inches thick at the top of the caps. The caps were cut so as to fit the dovetail. With this design the effectiveness of the tenon is greatly increased to resist an upward force.

FLOORING.

The flooring of the dam, excepting for 20 feet above and below the hinges of the gates, consists of two courses of timbers. The lower one is 6 inches thick, and is fastened to the caps with $\frac{1}{2}$-inch by 14-inch boat spikes, two at the ends of timbers, and one at each intersection, with a cap. The second course is of 3-inch plank, fastened to the first course with $\frac{3}{8}$-inch by 7-inch boat spikes, two at each end of a plank and one every two feet, alternating from side to side. The 3-inch plank in the recesses have $\frac{1}{2}$ by $\frac{1}{2}$ inch grooves in the sides, in which are inserted $\frac{1}{2}$ by 1 inch tongues of seasoned pine. After the flooring was laid it was calked with oakum and cemented under pressure. A $2\frac{1}{2}$-inch auger hole was bored about 2 inches in the 3-inch plank, and then through the rest of the floor with a 2-inch auger. Then a 2-inch gas pipe, 16 feet long, with a coupling on the lower end, was inserted, and a hydraulic liquid cement injected under a 16-foot head. All crevices between and under the floor were then filled. This was done to cut off leakage.

The floor of the log sluice and 5 small gates is at an elevation of 1,209 feet above sea level, and that of the navigable pass 1 foot lower. At the line where the first half of the dam terminated, two rows of 3-inch sheeting 8 feet long were driven 6 inches apart. Notches in which the caps would fit were cut through them, the caps laid, and the sheeting cut on a level with the top of the caps. After this the space between the lines of sheeting was filled with concrete and the floor laid. This was done to cut off leakage from underneath the floor when the water should pass through the first half of the dam.

CRIB WORK.

The walls of the crib work are of 12 by 12 inch timber, fastened together with 1 by 20 inch drift bolts of round iron, excepting a portion of the last 5 feet of the navigable pass piers, where 6 by 12 inch timbers taken out of the cofferdam were used. The 6 by 12 inch timbers were fastened with ½-inch by 14-inch boat spikes. For the 12 by 12 inch walls the ties are of 12 by 12 inch timber, and for the 6 by 12 inch portion they are of 6 by 12 inch timber. The ends of all ties are dovetailed and fit into corresponding gains in the walls. The dovetail is 12 inches long and 8 inches thick at the neck.

At the corners of piers a square lap was used and the corners bolted with ¾ inch by 12 inch bolts.

Commencing at the south side of the dam, the crib work is as follows: First is the south shore pier, 16 feet wide, 116 feet long, and 16 feet high for the first 73 feet from the upper end, and stepping down about 2 feet in 9 feet to a height of 10 feet above the floor. At each end is a wing wall 14 feet long extending into the bank. The upper one is 10 feet wide and the lower one 8 feet wide. Then comes the log-sluice opening 11 feet wide, followed by the log-sluice pier 12 feet wide, 68 feet long, and 16 feet high, to which is connected the crib work of the 5 small sluices. This is 18 feet wide, 16 feet high, and 34 feet long, and is connected on the right with the south-shore pier of the navigable pass, which is 12 feet wide, 17 feet high, and 249 feet long. Next is the navigable pass 40 feet wide, and, lastly, the north or right-hand shore pier of the navigable pass, 16 feet wide, 17 feet high, and 249 feet long. The log sluice and navigable pass are lined with 3-inch plank up to the flowage line, having a tongue of seasoned pine ½ by 1 inch inserted in ½ by ½ inch grooves in the edges of the plank. The plank are well spiked to the walls with ⅝-inch by 7-inch boat spikes. All piers are filled with rock and planked on top with 3-inch plank. They are 5 feet 3 inches above the flowage line.

FLUMES.

The right-hand pier of the log sluice and each of the navigable-pass piers are provided with flumes extending from end to end of piers, and are connected with the recesses underneath the gates with ports of suitable dimensions. The floor of the flumes are on the same level as the floor of the dam. They are 2 feet high, and the walls are of 12 by 12 inch timber tied into the pier walls with 12 by 12 inch ties. The log-sluice flume is lined with inch boards, and the two other flumes with 2-inch plank; and in both cases the lumber was jointed and placed vertically on the walls. They were covered with 6 by 12 inch timbers, with ½ by ½ inch grooves near the under side, in which are inserted ½ by 1 inch tongues of seasoned pine. Six inches from the ends of this covering in the joints are driven 1-inch stop waters of oak. The net width of the log-sluice flume is 1 foot 10 inches, and that of the others 2 feet 10 inches. Owing to the construction of the valves controlling the water in the flumes, the clear opening in the log-sluice flume is 1½ by 2 feet, or 3 square feet. The clear opening of the navigable-pass flume is 2 feet 5 inches by 2 feet, or 4.83 square feet. The flumes at the ends are flared out and grates of half-inch round iron put in to prevent anything larger than an inch in thickness from entering.

The flumes at the ports are controlled by reciprocating valves revolving on horizontal axes. On each valve-shaft is a large sprocket-wheel connected with a small one on a frame at the top of the pier with a combination of chains and rods, which are adjusted to the proper tension with turn-buckles. On the shaft of the smaller sprocket-wheel is a 6-foot power wheel which operates the valve. By manipulating the valve of a gate, the crest of the gate may be held in any desired position.

The flumes above the valves are provided with gates, so that if there is anything wrong with the valves the water on the upstream side can be cut off. Above the valve for the lower gate and at the side of the lock is a flume extending across the south piers controlled by two gates, one on each side of the main flume. They are to be used for filling or emptying the lock. The flume in the right-hand pier below the valve for the upper gate is connected with the lock chamber by a short flume controlled by a gate for the purpose of emptying the chamber. These small gates in the flumes are raised and lowered by means of racks on the posts worked by levers.

SLUICE GATES.

The five sluice gates are operated by worm-gear machines with pinions meshing in racks on the gate posts.

ROCK.

All the rock required was gathered around Sandy Lake and hauled in by teams in the winter time, excepting 400 cubic yards that were hauled by wagons. It was used in filling the piers and in riprapping above and below the dam. The amount of rock used was 5,360 cubic yards.

RIPRAPPING.

The bed of the river for a distance of 10 feet above and below the dam, and outside of the south-shore pier of the navigable pass for the same distance, was covered with brush fascines about a foot deep. The slopes at the upper and lower ends of the shore piers were covered with a layer of 6 inches of gravel. Both the brush and gravel was then covered with about a foot of rock.

LOG SLUICE AND NAVIGABLE-PASS GATES.

As previously referred to, the log sluice and navigable pass are controlled by improved bear-trap gates. The special feature of these gates is that they can be operated under a direct or reversed head. Each is formed of three leaves—the idler, upstream, and downstream leaves. The upper ends of the upstream and lower ends of the downstream leaves are hinged to the floor of the dam. One end of the idler is hinged to the free end of the downstream leaf, and its free end laps and slides on the upstream leaf. The term idler is borrowed from the name of a corresponding leaf in the Parker gate, although in these gates its use is for a pressure leaf and is indispensable, while in the Parker it is to protect the hinged joint of the upstream leaf.

Its minimum length must be such that its free end will not leave the upstream leaf when the gate is up full height, and should form an obtuse angle in all positions with it.

The free ends of the upstream and downstream leaves are connected by $\frac{3}{4}$-inch iron chains, 2 feet apart, adjusted as to length so that when the gates fold to their beds there is no appreciable slack.

When the log-sluice gate is acting under a direct head—that is, from Sandy Lake—the free end of the upstream leaf must be under the downstream leaf, with the idler sliding on the upstream leaf. But when the head is reversed, the idler must also be reversed as well as the conditions of the free ends of the leaves. The construction is such that this can be done.

In the case of each of the two navigable-pass gates the position of the idler and leaves is not changed, but the gate, instead of acting as an improved bear trap, acts as an old bear trap. In each of these is another set of chains of $\frac{5}{8}$-inch iron, 2 feet apart, connecting the heel of the downstream leaf with the free end of the upstream leaf to prevent the end of the upstream leaf which moves against the under surface of the downstream leaf from leaving it when up full height. The free end of the upstream leaf is provided with $5\frac{1}{2}$-inch cast-iron rollers, with journals $1\frac{1}{8}$ inches in diameter, to reduce the friction between the two leaves while the gate is rising under the conditions of an old bear trap gate.

The timbers to which the leaves of all gates are hinged are of White and Norway pine and 20 feet long, and form the floor of the dam for this distance above and below the hinges. Those in the log sluice are 12 by 12 inches by 20 feet boxed 3 inches on the caps and driftbolted to them with 1 by 20 inch driftbolts of round iron. Before each stick was driftbolted it was wedged firmly to the preceding one. Those in the navigable-pass gates are 11 by 12 inches by 20 feet, boxed 2 inches on tne caps, screwbolted together with three lines of screwbolts 2 feet long, of 1-inch iron, and driftbolted to the caps with 1 by 20 inch driftbolts of round iron. The gains extended 2 inches on each side of the caps for the purpose of keying the timbers to resist a pull or push. These keys were of seasoned oak.

The timbers in the log-sluice gate are of Norway dressed to the dimensions 7 by $11\frac{3}{16}$ by 21 feet 6 inches. The idler is of $\frac{3}{16}$-inch iron strengthened at the sides by two 3 by 3 inch angle irons, and between these by ten 3 by 5 inch T-irons. At the ends it is provided with rollers 2 feet apart to reduce the friction between it and the leaf on which it slides. In constructing the leaves a $\frac{3}{16}$-inch by 6-inch plate of iron was placed in the joints with dowels of 1 by 11 inch iron 1 foot apart, passing through the plates and into the adjacent timbers. This was done both to add strength and weight to the leaves. The timbers of the leaves are bound together by three 1-inch screw bolts passing through them from side to side, one near each end and one in the middle. A 2-inch rod was passed through the free ends, on which turn the cranks to which the chains and idler are attached. The under side of the leaves is covered with inch matched lumber to prevent leakage. The upper side of the lower leaf is covered with $\frac{3}{16}$ by 6 inch iron to prevent the leaf from being worn by logs. The floor of the log sluice for a distance of 30 feet below the hinges is covered with railroad iron. The upper leaf has $\frac{3}{16}$ by 6 inch straps bedded into the wood, on which the rollers on the free end of the idler travel. Hinges are on each stick of the leaves. The ends of the floor timbers, to which the hinges are attached, are anchored into a 12 by 14 inch stick of oak which passes under the walls of the piers. Each timber in the floor was boxed for 2-inch screw bolts and the boxing extended down through the oak timbers. A plate of iron 1 by 4 inches was then bedded in the underside of

each oak stick and tapped for 1-inch screw bolts. The bolts were then screwed into the plates, which answered for nuts and washers. At the upper ends of the bolts nuts and cast-iron washers were used.

To prevent leakage at the sides of the upstream and downstream leaves of the log-sluice gates there was left half an inch of play between the sides of the leaves and the walls. A triangular strip 3 inches wide and 3 inches high was then cut out of the lower sides of the leaves. This was replaced by a triangular strip somewhat larger than that cut out, resting on steel springs attached to the leaves. The springs keep the strips pressed against the walls, and in this way the leakage is cut off. The idler is 10 feet 11⅓ inches wide, with one-fourth of an inch play at each side. All timbers were sized.

The upper and lower leaves of the upper gate of the pass are each 13 feet 9⅞ inches long, the upper timbers being of 8 by 12 inches, and the lower of 9 by 12 inches white pine. The timbers of the upstream leaf of the lower gate are 8 by 12 inches by 16½ feet, and that of the downstream leaf 9 by 12 inches by 15 feet 7 inches in dimension and all of white pine. The idlers of both gates are of oak. The timbers in the idler of the upper gate are 4¼ by 12 inches by 9 feet, and those in the idler of the lower gate 4¼ by 12 inches by 11 feet 5½ inches in dimension. The timbers of all the leaves, including the idlers, are screw-bolted together with three lines of bolts 2 feet long, one line in the middle and one near each end. There were also in the joints 11-inch dowels of round iron and about 2 feet apart. The screw bolts and dowels in the downstream leaves were of 1-inch iron, those in the upstream leaves ⅞-inch iron, and those in the idlers are of ¾-inch iron. At the free ends of the downstream leaves, just below the idler hinges, are two continuous straps of ½-inch by 4-inch iron. One strap is on the upper surface and the other opposite and bedded its thickness in the under side. They are connected together by two ⅝-inch bolts to every foot of length. They were put on to bind the free ends of the downstream leaves more firmly together.

To prevent leakage between the timbers of the leaves and idlers ½ by 1 inch tongues of seasoned pine were inserted in corresponding ½ by ½ inch grooves in the sides. The upstream and downstream leaves have ½ inch play at the walls. Oak cleats 1½ by 5 inches, with the side next to the wall beveled, were screw-bolted to the side timbers with ⅝-inch bolts. After they were bolted on a saw was run through between the cleats and the walls, leaving a clearance of ⅛ inch to $\frac{3}{16}$ inch. The same amount of clearance was left at the idlers, but cleats were not used on them.

The hinges of the idlers, to which are attached the chains connecting the free ends of the leaves, are on the same timbers that hinges are on. The chains attached to staples in the hinges of the lower leaves are not connected to opposite timbers in the free ends of the upstream leaves, but are swung to the left upstream 9 inches and are attached to timbers on which there are no hinges.

The blank timbers in the leaves at the lower ends are connected with those having hinges by means of 4 by 12 by 18 inch oak blocks. These blocks lap on the adjacent timbers 3 inches and are connected with the blank timbers with four 1-inch screw bolts. This transfers the strain due to pressure on the blank timbers to the hinges. Similar blocks connect the free ends of the blank timbers in the upstream leaves with the adjacent timbers. In this case, however, the bolts pass through the ends of the oak blocks into the hinged timbers. This is to resist the opposite pull of the chains when the gate is up full height. The ends of the timbers in the floor to which the hinges are attached are anchored to the caps of a row of round piles next to the triple-lap sheeting by 1¾-inch bolts 2 feet apart. There are also two 1-inch screw bolts going through the first cap below the triple lap-sheeting. Besides this there are 6-inch timbers bolted with drift and screw bolts to the triple-lap sheeting. After they were bolted wedges of hard wood were driven under them, so that when a lift comes on the caps the sheet-piling comes into play to resist the upward force of the water.

After the gates were completed a line of 3-inch plank was placed at the ends of the timbers to which the lower hinges are attached, and the space inside filled with gravel, and then a liquid cement was injected through a 2-inch gas pipe 16 feet long. This was done to cut off the lift on the ends of the timbers when the lower leaves are under pressure.

To guard against the effects of a slight lift of the timbers to which the hinges are attached, a slot 2 by 6 inches is cut in each timber just over the triple-lap sheeting so as to allow any water to escape in case such should occur. About half way between the first two caps below the hinges a 2-inch auger hole was bored in each timber to further facilitate the escape of any water that might come from the recess.

After the rollers with their boxes were put on the free ends of the upstream leaves they were raised up the full height to which they rise under a reversed head, and the positions of the slots were marked on the free ends of the downstream leaves. The upstream leaves were then lowered and the straps and staples put on the free ends of the downstream leaves. The slot between the boxes for the rollers is 2¾

inches wide, and the width of the $\frac{3}{4}$-inch chains is $2\frac{1}{2}$ inches; and as the chains must pass through the slots, it is very important that the staples in the free ends of the downstream leaves should coincide with the center line of the slots.

The chains connecting the heel of the downstream leaves with the free ends of the upstream leaves are provided with turn-buckles at their lower ends, and in adjusting them the gates were raised full height as an old bear trap gate by means of jack-screws when a uniform tension was put on them. By means of tackle the downstream leaves were next raised up full height and the short chains subjected to a uniform tension. This was done by means of the staples in the free ends of the downstream leaves.

In a model made to see whether or not the chains would drop back through the slots between the boxes when the gate is used as an old bear trap or under a reversed head, it was found that they would not without a weight of 28 pounds attached to the chain at the slot. Cast-iron balls weighing 32 pounds, with $\frac{3}{8}$-inch staples, were attached to the $\frac{3}{4}$-inch chains with $\frac{3}{8}$-inch chains about a foot long to insure their falling back. After the chains were adjusted the gates were lowered to their beds and the water in the cofferdam was allowed to raise over the floor of the pass. It was found that the upstream leaves with all the irons on them would not float and that the lower ones would not sink. Spruce plank were fastened to the free ends of the upstream leaves on the under side until they floated. The idlers were then built and placed on the leaves. Each idler is provided with ten valves to allow the water to escape that passes through the chain holes when the gates are acting under a reversed head. Three-eighths holes were bored in the idler timbers near the hinges to create an air pressure between the idler and the upstream leaf when the gates are acting under a reversed head so as to prevent the water from rising up and adding weight on the upstream leaves.

After the idlers were put on railroad iron was laid transversely across the downstream leaves just below the hinges of the idler until the gates would sink in still water.

After the gates were completed a test was made as to the head that would lift each gate, and it was found that a head of 2 inches would raise the upper gate and 3 inches the lower gate of the navigable pass, while it took a head of about 5 inches to raise the log sluice gate.

AIR BAGS AND CAPSTANS.

When the head is less than two or three inches, or so small that it will not raise the gates, provision is made to raise them above the water line so that the water may be held on either side of the dam by means of air bags and capstans, either of which is sufficient to raise them.

In the navigable pass gates there are attached to each of the upstream leaves four air bags, each 8 feet 10 inches long and 2 feet in diameter. Each air bag is connected with an air pump on top of the pier with a half-inch hose through which air is forced into the bags and inflated. The pipes and valves at the air pumps are so arranged that all the air bags may be simultaneously inflated, or any one of them may be inflated or emptied independently of the others. The log sluice gate has one air bag on each leaf These air bags are made of 2-ply special woven 16-ounce duck, heavily coated with pure Para rubber. In the navigable pass gates the lines of hose pass under the bed support for the gates and up through a well in the pier at the lower corner of each gate. In the log sluice gate the bolt for the hinges is a continuous hollow bar of brass 2 inches in diameter and $\frac{13}{64}$ inch thick, closed at one end and made fast to the hinge straps on the leaves so as to render it stationery with reference to the leaves. To the center of it is attached a half-inch gas pipe which extends along the under surface of the leaves to the air bag and is attached to a short rubber nipple at the center of the bag. To the ends of the hollow rods are attached elbows and reducers to half-inch pipes which are connected with half-inch hose to the air pump. In case the air bags should fail to raise the gates of the navigable pass, each gate is provided with two powerful capstans which can be connected with $\frac{3}{4}$-inch chains 12 feet long attached to the free ends of the downstream leaves near the sides. Two similar chains are attached 10 feet from the sides which can be used with derricks should occasion require it.

DIKE.

The diaphragm of the dike was formed by driving two rows of 1 by 12 inch boards close together and breaking joints. They were driven into the ground about 3 feet and were cut off 1 foot above the flowage line. It is 6 feet wide on top, with slopes 3 horizontal to 1 vertical, and has a total length of 620 feet, and is $4\frac{1}{2}$ feet above the flowage line. The embankment was put it with scrapers, and the material consists of sand and sandy loam and is covered with 6 inches of sod.

Timber in diaphragm, 6,064 feet B. M.; embankment, 2,454 cubic yards. The quantity of embankment includes a 6-inch coating of sod.

The total amount of iron purchased for the dam, not including machinery, rollers, valves, etc., was 192,383 pounds. This is an average of 163.4 pounds per 1,000 feet B. M. for all timber put in place in the dam and dike. A portion of this iron was railroad iron for protecting the floor of the log sluice and for weighting the gates of the navigable pass.

The number of rations consumed during the construction was 39,798, at an average cost of 26.6 cents per ration. This only includes the cost of groceries and meats with transportation added.

The following rates were paid to laborers for a day of eight hours, viz: 80 cents, 88 cents, 92 cents, and $1.16. Up to the middle of August, 1892, the crew worked ten hours each day, but after that they only worked eight hours each day. This feature in the eight-hour law added considerably to the cost of the work, as board was furnished.

The cost of the dam was	$112,676.77
Watchmen's quarters	1,299.49
Total	113,976.26

In conclusion I have to acknowledge my indebtedness to Mr. George Snetsinger, overseer, for valuable services in carrying on the work.

Very respectfully, your obedient servant,

ARCHIBALD JOHNSON,
Assistant Engineer.

Lieut. Col. W. A. JONES,
Corps of Engineers, U. S. A.

Y 2.

OPERATING AND CARE OF RESERVOIRS AT HEAD WATERS OF MISSISSIPPI RIVER.

The river and harbor act of August 17, 1894, made applicable to the reservoirs at head waters of the Mississippi River, "so far as concerns their care, preservation, and maintenance," the provisions of the general appropriation for "operating and care of canals and other works of navigation, indefinite," contained in section 4 of the river and harbor act of July 5, 1884. The first allotment was made January 25, 1895, and the expenses from February 1, 1895, have been paid from the indefinite appropriation.

There are five completed reservoirs, viz:

At Lake Winnibigoshish, completed in 1883–84; height of dam, 14 feet; capacity, 45,800,000,000 cubic feet.

At Leech Lake, completed in 1884; height of dam, 6 feet; capacity, 30,000,000,000 cubic feet.

At Pokegama Falls, completed in 1884; height of dam, 7 feet; increased in 1889 to 9 feet; capacity, 4,700,000,000 cubic feet.

At Pine River, completed in 1886; height of dam, 17 feet; capacity, 7,500,000,000 cubic feet.

At Sandy Lake, completed in 1895; height of dam, 9.4 feet; capacity, 3,000,000,000 cubic feet.

The location of the reservoirs is shown upon the map accompanying the report upon reservoirs at head waters of Mississippi River.

The maximum quantity of water held in the reservoirs at any one time since their completion was:

In Lake Winnibigoshish Reservoir, July, 1888, 21,300,000,000 cubic feet.
In Leech Lake Reservoir, June, 1896, 18,900,000,000 cubic feet.
In Pine River Reservoir, June, 1896, 5,700,000,000 cubic feet.
In Pokegama Falls Reservoir. This reservoir can be filled each year.
In Sandy Lake Reservoir. This reservoir can be filled each year.

The purpose of the reservoirs is to collect the surplus water principally from the precipitation of winter, spring, and early summer, to be systematically released so as to benefit navigation upon the Mississippi River below the dams and as far down as Lake Pepin. Reduction of heights of floods in localities immediately below the dams is expected to obtain to some extent, but control of extended floods or freshets is not expected.

EFFECT OF THE RESERVOIR WATER.

The Board of Engineers, in their report dated May 24, 1887, and printed on pages 1681–1698, Annual Report of the Chief of Engineers, 1887, express this opinion:

> As far down as the mouth of the first considerable tributary, the St. Croix, it is therefore not unreasonable to suppose that navigation may be benefited nearly in proportion to the effect upon the St. Paul gauge, i. e., from 1 foot to 18 inches of low-water stages.

The two plates published opposite page 2205, Annual Report, 1895, and the plate accompanying this year's report upon gauging the Mississippi River at or near St Paul, Minn., show the dates for releasing water and the effect of the reservoir water upon the Mississippi River at St. Paul during the low-water periods of the years 1893–1895. The three records indicate that a rise in the river at St. Paul commences in seven or eight days following the release of water from the distributing reservoir at Pokegama Falls and in about five days thereafter the full effect is felt. The mean time is therefore ten days. The rise on the signal service gauge, St. Paul, due to the reservoir water in 1893 was 1 foot; in 1894, 1.3 feet; in 1895, 1.2 feet.

CARE AND MAINTENANCE OF RESERVOIRS DURING THE FISCAL YEAR ENDING JUNE 30, 1896.

A force of watchmen, consisting usually of two men at each dam, were employed in operating the dams and guarding United States property stored at them, and also in taking hydrological and meteorological observations. A force of three men in addition to the watchmen aided in the hydrological work. One assistant engineer, Mr. Archibald Johnson, at a salary of $180 per month, divided his time between the completed reservoirs and the construction of the Sandy Lake Dam. The latter dam was completed in October, 1895.

At Leech Lake Dam.—That portion of the timber structure comprising the 51 high-floor sluices, aggregating 405 feet in length, was replaced by an embankment. The west shore connection was strengthened by building an abutting pier 9 by 22 feet and 10 feet high on the apron below the first sluiceway. The Leech Lake Dam is 3,600 feet in length, consisting originally of 2,600 feet of embankment and 1,000 feet of timber structure. The respective lengths of embankment and timber work are now 3,005 feet and 595 feet.

At Pokegama Falls Reservoir.—A dike 88 feet long and 4¼ feet high in the middle was built at the southeast arm of Pokegama Lake, to close a depression in the ridge separating Pokegama and Hale lakes. The dike is 10 feet wide at the top and has slopes of 3 horizontal to 1 vertical. A diaphragm of 3-inch plank extends about 4 feet into the ground below the level of the lowest place. The sheeting was cut off about 3 inches below the top. The earth material in the dike is sand and sandy loam, laid up with slush scrapers.

Amount of material in dike: Lumber, 2,112 feet, B. M.; earth, 180 cubic yards.

The hydrological and meteorological records kept at the dams furnish

interesting data concerning the relation of run-off to rainfall for extensive watersheds. The records since 1885, inclusive, at the three upper dams—Leech Lake, Lake Winnibigoshish, and Pokegama Falls, the latter being the distributing reservoir for the other two—have been compiled in the following table:

Relation of run-off to rainfall on the watershed of the Mississippi River above Pokegama Falls Reservoir Dam, years 1885–1895, inclusive.

Area of watershed ..... square miles.. 3,265
Area of watershed, less lake areas ..... do..... 2,681

Year.	Rainfall.					Total rainfall, million cubic feet.			
						By calendar years.		Since January 1, 1885.	
	2	3	4	5	6	7	8	9	10
	At Pokegama Falls reservoir dam.	At Lake Winnibigoshish reservoir dam.	At Leech Lake rservoir dam.	Mean assumed for entire watershed.	Total of assumed mean since Jan. 1, 1885.	Over entire watershed.	Over entire watershed, less lake areas.	Over entire watershed.	Over entire watershed, less lake areas.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*				
1885	23.66	28.57	22.74	24.99	24.99	189,555	155,650	189,555	155,650
1886	25.94	26.80	22.94	25.22⅔	50.21⅔	191,351	157,124	380,906	312,774
1887	27.45	24.70	24.69	25.61⅓	75.83	194,283	159,533	575,189	472,307
1888	27.14	27.79	29.14	28.02⅓	103.85⅓	212,564	174,543	787,753	646,850
1889	25.65	21.35	21.59	22.86⅓	126.71⅔	173,424	142,404	961,177	789,255
1890	26.63	24.29	26.03	25.65	152.36⅔	194,562	159,761	1,155,739	949,016
1891	25.02	25.38	24.18	24.86	177.22⅔	188,569	154,840	1,344,308	1,103,856
1892	20.19	20.98	22.83	21.33⅓	198.56	161,819	132,875	1,506,127	1,236,731
1893	26.24	25.91	24.11	25.42	223.98	192,817	158,328	1,698,944	1,395,059
1894	32.01	23.46	24.41	26.62⅔	250.60⅔	201,970	165,844	1,900,914	1,560,903
1895	26.53	25.94	22.86	25.11	275.71⅔	190,466	156,398	2,091,379	1,717,301

Year.	Run-off, million cubic feet.				Proportion of run-off to rainfall.				Average volume of run-off per second per square mile.			
	By calendar years.			Since Jan. 1, 1885.	By calendar years.		Since Jan. 1, 1885.		By calendar years.		Since Jan. 1, 1885.	
	11	12	13	14	15	16	17	18	19	20	21	22
	Water released from the distributing reservoir at Pokegama Falls.	Water held in reservoirs Dec. 31, in excess (±) of that contained on the preceding 1st of January.	Total run-off.	Total.	For entire watershed.	For entire watershed, less lake areas.	For entire watershed.	For entire watershed, less lake areas.	For entire watershed.	For entire watershed, less lake areas.	For entire watershed.	For entire watershed, less lake areas.
					P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
1885	36,988	+10,460	47,448	47,448	25.0	30.5	25.0	30.5	0.46	0.56	0.46	0.56
1886	38,840	—11,735	27,105	74,553	14.2	17.3	19.6	23.8	.26	.32	.36	.44
1887	27,522	— 4,907	22,615	97,168	11.6	14.2	16.9	20.6	.22	.27	.31	.38
1888	44,776	+18,372	63,148	160,316	29.7	36.2	20.4	24.8	.61	.74	.39	.47
1889	34,363	—22,109	12,254	172,570	7.1	8.6	17.9	21.9	.12	.14	.34	.41
1890	22,892	+ 3,311	26,203	198,773	13.5	16.4	17.2	20.9	.25	.31	.32	.39
1891	22,321	+ 1,651	23,972	222,745	12.7	15.5	16.6	20.2	.23	.28	.31	.38
1892	25,028	+ 8,659	33,686	256,431	20.8	25.4	17.0	20.7	.33	.40	.31	.38
1893	29,920	— 2,559	27,361	283,792	14.2	17.3	16.7	20.3	.27	.32	.31	.37
1894	30,126	— 2,609	27,517	311,309	13.6	16.6	16.4	19.9	.27	.33	.30	.37
1895	27,880	— 6,641	21,239	332,548	11.1	13.6	15.9	19.4	.21	.25	.29	.36

The mean rainfall has been assumed equal to the mean of the measurements at each of the three dams, though the position of the dams are in the eastern portion of the watershed. The situation is shown on the map accompanying the report on reservoirs at head waters of Mississippi River.

An unfortunate accident occurred at the Pine River reservoir June 17 last, entailing considerable loss upon several settlers and the Government. At one point on the southern boundary of the reservoir the waters were separated from the Pelican Creek watershed by a sand ridge 150 feet wide and about 10 feet higher than the flowage line of the reservoir. It appears that a logging firm cut a road through the ridge without this office being advised of the fact. When the water in the reservoir reached a stage of 15.34 feet on the gauge (18.5 feet would have been a full reservoir) it flowed down the road, quickly scouring an opening through the sand ridge 230 feet wide to a depth of minus 2 feet on the gauge.

The water poured through the opening, inundating the valley of Pelican Creek. Severe damage was inflicted upon the lowlands, and the buildings of one settler were mostly demolished or carried away.

A crew of men was quickly assembled, and by rapid work a brush dam was built to a height sufficient to save a portion of the water and prevent additional damage to settlers.

An allotment of $5,000 was made by the Secretary of War June 20, 1896, for temporary work in closing the breach; $1,274.79 of the sum was expended in June. The total cost of the temporary work is now estimated at $3,274.79.

Estimate for the fiscal year ending June 30, 1897, exclusive of cost of permanently closing the breach in the Pine River Reservoir. An estimate of the latter has not yet been prepared:

1 assistant engineer, 12 months, at $180	$2,160.00
1 watchman and head lock tender, 12 months, at $100	1,200.00
1 watchman and dam tender, 12 months, at $75	900.00
2 watchmen and dam tenders, 12 months, at $60 each	1,440.00
3 watchmen and dam tenders, 12 months, at $50 each	1,800.00
1 watchman and dam tender, 8 months, at $50	400.00
3 watchmen and dam tenders, 12 months, at $30 each	1,080.00
1 watchman and dam tender, 8 months, at $30	240.00
1 recorder and boatman, 12 months, at $90	1,080.00
1 recorder and boatman, 12 months, at $75	900.00
1 boatman, 12 months, at $45	540.00
Subsistence of 11 employees, 12 months, at $20 each	2,640.00
Subsistence of 2 employees, 8 months, at $20 each	320.00
Traveling expenses	500.00
Ordinary repairs to the 5 completed reservoir dams, repairs to lines of communication between the reservoirs, tools, and instruments, and repairs to tool and instruments	5,000.00
Quarters for watchmen at Pokegama Falls Reservoir Dam, to replace old construction building used as quarters	3,000.00
Completion of temporary low brush dam at break in Pine River Reservoir	2,000.00
Contingencies and St. Paul office expenses	2,500.00
Total	27,700.00
Balance available July 1, 1896	4,228.02
Total	23,471.98

For commercial statistics reference must be made to the reports upon the improvement of the Mississippi River.

MAP
OF RESERVOIR WATERSHEDS IN MINNESOTA.

SCALE, OF STATUTE MILES.

0 5 10 20 30 40

EXPLANATIONS,

RESERVOIR BASINS.

1	LEECH LAKE	Reservoir built 1884
2	LAKE WINNIBIGOSHISH	" " "
3	POKEGAMA FALLS	" " "
4	PINE RIVER	" " 1886
5	SANDY LAKE	" " 1895
6	GULL LAKE	Reservoir Proposed
7	MILLE LACS	Examination Ordered June 3d 96
8	CROW WING RIVER	
9	BIG STONE LAKE	Survey Ordered June 3° 1896.
10	LAKE TRAVERSE	
11	OTTER TAIL LAKE	Exam. Ordered June 3° 1896.
12	RED LAKE	" "

To accompany Annual Report 1896.

W. A. Jones
Lieutenant Colonel
Corps of Engineers,
U.S.A.

G.T.B.

ANDREW B. GRAHAM, PHOTO-LITHO, WASHINGTON, D.C.

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Money statement.

July 1, 1895, balance unexpended	*$30,738.05
Amount allotted June 20, 1896, for temporarily repairing break in Pine River Reservoir	5,000.00
	35,738.05
June 30, 1896, amount expended during fiscal year	26,801.98
July 1, 1896, balance unexpended	8,936.07
July 1, 1896, outstanding liabilities	4,708.05
July 1, 1896, balance available	4,228.02

Itemized statement of expenditures during the fiscal year ending June 30, 1896.

Date.	To whom paid.	For what paid.	Amount.
1895.			
July 18	A. O. Powell	Traveling expenses	$19.45
31	Sundry persons	Pay roll for July	850.00
Aug. 6	Soren Denesen	Services	4.50
	George Dufour	do	16.67
7	Sundry persons	Pay roll for July	97.00
	do	do	453.00
	do	do	62.33
12	Globe Building Co	Rent	85.00
	J. W. Taylor	Light and heat	25.00
	Sam V. Morris	Services	60.00
16	George Dufour	do	10.00
	H. E. Wedelstaedt & Co	Stationery	43.53
	Noyes Bros. & Cutler	Office supplies	3.91
	Archibald Johnson	Traveling expenses	13.81
	Duluth and Winnipeg Rwy. Co	Express charges	2.00
	Adams Express Co	do	1.70
	Riddle & Son	Team hire	6.00
23	North American Telegraph Co	Telegrams	7.06
	W. B. Hale & Co	Telephone supplies	.60
	Brown, Treacy & Co	Paper and twine	9.25
	do	Letter-press book	1.50
	Independent Telephone Co	Repair work	3.45
	D. W. Collies	Services	10.50
	Wm. B. Hale & Co	Repair work	1.50
27	A. Purdy	Team hire	6.00
	E. A. Brown	Timers	16.00
	American Express Co	Express charges	1.55
31	Sundry persons	Pay roll for August	610.00
Sept. 2	John E. Dempsey	Bills of lading	9.00
6	Sundry persons	Pay roll for August	453.00
	do	do	608.09
	do	do	89.00
	Soren Denesen	Services	4.50
	Archibald Johnson	Traveling expenses	11.70
	do	do	13.40
	do	do	20.44
11	D. D. McLennan	Services	10.00
	Independent Telephone Co	Telephone supplies	19.00
	Robinson & Cary Co	Manila rope	71.07
	do	Boat spikes, etc	37.77
	Lewis Wilson	Round piles	81.48
	C. H. Marr	Subsistence and forage	856.98
	do	Transportation	3.87
	do	Mess supplies, etc	339.67
	Ryan Drug Co	Oil, etc	45.18
	Nicols & Dean	Bellows	9.00
	W. J. & H. D. Powers	Hardware, paint, etc	41.76
	do	Iron, etc	5.04
	do	Blacksmith coal	5.02
	John Lyons	Services	1.50
	Pioneer Press Co	Office supplies	31.00
	J. W. Taylor	Light and heat	25.00
	Globe Building Co	Rent	85.00
	Bert Humberstone	Services	14.00
	Brown, Treacy & Co	Cards	5.50
	John Jackson	Services	2.00
	Wyckoff, Seamans & Benedict	Typewriter oil	.40
	Northern Pacific Express Co	Express charges	.60
	C. H. Marr	Transportation	2.63

*In Annual Report for 1895 this amount was given as $31,911.14, but on July 1, 1895, the sum of $1,173.09 was covered back into the Treasury.

Itemized statement of expenditures during the fiscal year ending June 30, 1896—Continued.

Date.	To whom paid.	For what paid.	Amount.
1895.			
Sept. 11	American Express Co	Express charges	$0.80
	Cloquet Lumber Co	Lumber	582.64
	American Express Co	Express charges	.80
14	North American Telegraph Co	Telegrams	1.29
	F. E. Messing	Dater	.75
20	Adams Express Co	Express charges	.95
	De Coster & Clark Co	Excelsior	1.50
	H. E. Wedelstaedt & Co	Drawing paper, etc	12.65
	The Western Supply Co	Hancock inspirator, etc	24.58
	Nicols & Dean	Nails, iron, etc	211.21
24	Harry J. Miller	Lumber	590.40
	J. P. Sims	Trackage	7.50
30	Sundry persons	Pay roll for September	185.00
Oct. 1	Richard Relph	Services	75.00
5	Sundry persons	Pay roll for September	469.50
7	Archibald Johnson	Traveling expenses	5.70
	Brainerd and North Minnesota Rwy. Co	Freight charges	472.32
	C. H. Marr	Transportation	33.00
	.....do	.....do	209.00
	.....do	Fresh meat	2.10
	.....do	Transportation	101.46
	St. Paul Foundry Co	Pinion	4.82
	Robinson & Cary Co	.....do	6.25
	Joseph Crowther	Transportation	50.31
	People's Ice Co	Ice	7.26
	James Sullivan	Transportation	5.00
	Adams Express Co	Express charges	.55
	Sundry persons	Pay roll for September	80.00
	.....do	.....do	678.07
10	Sam V. Morris	Services	50.00
	Bert Humberstone	.....do	5.63
15	Chas. J. White	.....do	3.00
25	W. J. & H. D. Powers	Galvanized elbows, etc	.56
	.....do	Hardware, etc	62.24
	.....do	.....do	52.38
	.....do	Stovepipe	1.80
	D. D. McLennan	Services	10.00
	Lewis Wilson	Hay	19.25
	.....do	Milk	7.70
	N. Dolly	Transporting lumber	177.12
	Robinson & Cary Co	Wire rope	8.32
	.....do	Horizontal drill	3.00
	J. W. Taylor	Light and heat	25.00
	Globe Building Co	Rent	85.00
	S. & J. W. Knox	Mess supplies	73.04
	A. D. Brooks & Co	Tin dishes	2.20
	American Bell Telephone Co	Rental ($6.05 less $1.06)	4.99
	Beckfelt & Mather	Bread, beef, and cheese	1.68
	John Jackson	Onions and fresh beef	31.76
	Archibald Johnson	Traveling expenses	4.20
	.....do	.....do	18.13
29	Pioneer Press Co	Portfolios, blanks, etc	23.55
	.....do	Blanks	6.45
	.....do	Subscription	1.82
	The Western Supply Co	Pump fixtures	8.30
	Ryan Drug Co	Chemicals	1.27
	Brown, Treacy & Co	Staples	.25
	Wyckoff, Seamans & Benedict	Stationery	3.60
	Robinson & Cary Co	Manila rope	55.83
	Goodyear Rubber Co	Rubber boots	40.85
	.....do	Cement	.38
31	Sundry persons	Pay roll for October	477.50
Nov. 8	.....do	.....do	452.00
	.....do	.....do	693.24
	.....do	.....do	50.00
14	Western Union Telegraph Co	Telegrams	8.04
	Northern Pacific Express Co	Express charges	.30
	Lewis Wilson	Milk	4.30
	D. D. McLennan	Services	10.00
	Charley Drumbeater	Fresh meat	5.70
	A. C. Gould	Hauling	11.36
	Brown, Treacy & Co	Letter files	8.40
	Mrs. F. L. Churchill	Meals	.75
20	Sundry persons	Pay roll for October	80.00
22	George Snetsinger	Traveling expenses	8.05
26	W. J. & H. D. Powers	Hardware, etc	4.88
	.....do	Paper, glass, nails, etc	14.04
	John McDonald	Services	1.00
	The Western Supply Co	Pop valves, etc	3.42
	W. Potter & Co	Groceries, etc	25.35
	Northwestern Hardware Co	Rollers	1.25
	J. W. Taylor	Light and heat	25.00

Itemized statement of expenditures during the fiscal year ending June 30, 1896—Continued.

Date.	To whom paid.	For what paid.	Amount.
1895.			
Nov. 26	Globe Building Co	Rent	$85.00
	H. E. Wedelstaedt & Co	Stationery	12.88
	John Jackson	Fresh beef	41.16
27	Archibald Johnson	Traveling expenses	18.40
29	Griggs & Co	Groceries	130.85
	St. Paul Wall Paper Co	Wall paper	9.60
30	Sundry persons	Pay roll for November	150.00
	Ryan Drug Co	Paint	7.20
Dec. 4	Sundry persons	Pay roll for November	453.50
	do	do	874.09
	do	do	80.00
	do	do	90.00
10	A. D. Brooks & Co	Fresh meat	4.50
	do	do	15.25
	Charley Drumbeater	Fresh meat and fish	4.38
16	Sundry persons	Pay roll for December	75.00
	James Butt	Hauling	13.33
19	H. Rosenblatt	Hay	10.00
24	B. & C. Fairbanks	Fresh meat, etc	9.73
	North American Telegraph Co	Telegrams	1.38
26	C. H. Marr	Transportation	5.62
31	Sundry persons	Pay roll for December	75.00
1896.			
Jan. 2	Sundry persons	do	776.69
	do	do	450.00
	do	do	90.00
	Lieut. Col. W. A. Jones	Mileage	33.74
	Mrs. F. L. Churchill	Meals	2.50
6	A. D. Brooks & Co	Subsistence stores, etc	74.27
8	Sundry persons	Pay roll for December	80.00
	Eugene Libby	Hay	4.00
15	Sam V. Morris	Services	75.00
17	Eugene Libby	Hay	8.00
	Robinson & Cary Co	Ratchet drill	4.00
22	John Jackson	Services	4.00
	James Butt	Hauling	5.94
	Lieut. Col. W. A. Jones	Mileage	29.52
29	St. Paul Wall Paper Co	Border	.96
	St. Paul Hardware Co	Hardware, etc	20.73
	E. M. Parish	Boiler	44.00
	Patrick Henry	Traveling expenses	6.64
	Duluth and Winnipeg R. R	Rental ($16.58 less $1.58)	15.00
31	Mannheimer Bros	Iron bed, etc	29.50
	Sundry persons	Pay roll for January	225.00
Feb. 3	do	do	525.00
4	do	do	130.00
	do	do	80.00
	W. Potter & Co	Groceries	56.02
	do	Meat, etc	7.70
8	J. M. Romans	Hauling tank	1.00
13	Northern Pacific Express Co	Express charges	1.05
	H. Rosenblatt	Meat, hauling, etc	32.22
	do	Meat, etc	16.33
	Archie Purdy	Team hire	6.00
14	W. V. Fuller	Lumber	7.68
19	W. A. Ross	Services	10.00
21	Minnesota Packing and Provision Co	Meats	131.84
	Robinson & Cary Co	Hose, etc	10.20
	G. T. Brown	Traveling expenses	3.50
25	Standard Oil Co	Gasoline	1.01
27	Robinson & Cary Co	Pump	14.00
	Peteler Portable Railway Manufacturing Co	Castings	8.60
29	The Horne & Danz Co	Oil tanks	25.00
	Sundry persons	Pay roll for February	150.00
Mar. 6	do	do	450.00
	do	do	80.00
	John Doran	Team hire	15.00
	Beckfelt & Mather	Mess supplies, etc	207.83
	do	do	95.17
	do	do	22.69
	Sundry persons	Pay roll for February	140.00
7	John E. Dempsey	Blanks	3.00
13	Crescent Creamery Co	Butter	162.38
	H. Rosenblatt	Team hire, etc	9.91
	J. W. Griggs	Pears	1.75
	Fred B. Lawrence	Hauling supplies	76.09
	Frank Clifton	Beef, etc	33.44
	Griggs Bros	Oats, etc	52.06
16	St. Paul Hardware Co	Hardware	2.55
	Standard Oil Co	Kerosene	37.96
	North American Telegraph Co	Telegrams	.83
	Sam V. Morris	Services	75.00

Itemized statement of expenditures during the fiscal year ending June 30, 1896—Continued.

Date.	To whom paid.	For what paid.	Amount.
1896.			
Mar. 19	St. Paul Hardware Co	Hardware	$4.69
	S. & J. W. Koop	Groceries	48.44
	Northern Pacific Express Co	Express charges	.50
20	H. H. Perrine	Services	45.00
27	Boeringer & Son	Repair work	4.50
	H. Rosenblatt	Hauling, etc	100.44
31	Sundry persons	Pay roll for March	535.00
Apr. 3	....do	....do	455.00
	Ogden, Merrill & Greer	Lamps, etc	20.85
	Northern Pacific R. R. Co	Ticket	11.12
	Mrs. Etta Churchill	Meals	2.55
	Eugene Libby	Hay	30.00
	Bert A. Young	Services	11.00
4	H. H. Perrine	....do	45.00
6	Sundry persons	Pay roll for March	81.00
8	Frank N. Allen	Services	6.00
	Western Union Telegraph Co	Telegrams	.66
9	Sundry persons	Pay roll for March	140.00
20	Northern Pacific Express Co	Express charges	.45
	....do	....do	1.15
22	St. Paul and Duluth R. R. Co	Tickets	13.40
28	G. W. Knox	Groceries	66.78
	A. D. Brooks & Co	Fresh meat	3.72
30	Sundry persons	Pay roll for April	340.75
May 5	....do	....do	80.00
	....do	....do	140.00
8	....do	....do	450.00
	....do	....do	660.50
13	J. M. Romans	Hauling boiler, etc	1.00
	W. J. & H. D. Powers	Iron, nuts, etc	9.10
	Beckfelt & Mather	Garden seeds	6.83
	Geo. J. Grant	Moving	150.00
16	L. L. May & Co	Seed	.97
	Henry E. Wedelstaedt	Stationery	12.30
	Adams Express Co	Express charges	1.35
	Robinson & Cary Co	Boiler, etc	60.29
	Sam V. Morris	Services	75.00
	Wm. B. Hale & Co	Zincs, keys, etc	6.50
	North American Telegraph Co	Telegrams	1.96
26	Walter Taylor	Hauling	10.00
	St. Paul Hardware Co	Hardware	18.37
	Brown, Treacy & Co	Stationery	9.71
30	Sundry persons	Pay roll for May	736.00
29	Wm. B. Hale & Co	Furnishing bells, etc	66.00
June 4	Sundry persons	Pay roll for May	1,055.06
	....do	....do	140.00
	....do	....do	80.00
8	....do	....do	461.94
	Lieut. Col. W. A. Jones	Mileage	16.00
9	Western Union Telegraph Co	Telegrams	.64
	John Jackson	Services	7.50
	Kahlert & Hildebrandt	Meter weight	10.66
	Amos Forsythe	Services	4.13
	A. M. Black	....do	6.00
9	Zimmerman Bros	Dry plates, etc	4.23
	North American Telegraph Co	Telegrams	5.66
	A. Putney	Hauling lumber	1.00
	B. C. Finnegan	Oak lumber	5.79
	Northern Pacific Express Co	Express charges	1.50
	A. McWilliams	Team hire	8.00
	M. F. Kennedy & Bros	Oars	1.40
11	D. D. Wilson	Lumber	5.00
	Lewis Wilson	Hay	4.50
	E. A. Brown	Repair work	12.00
	Charley Wakefield	Meat, etc	10.00
	John E. Dempsey	Envelopes	5.10
	Lieut. Col. W. A. Jones	Mileage	21.38
15	Sam V. Morris	Services	75.00
16	Albertine Myers	....do	12.50
19	Janney, Semple & Co	Iron, etc	73.91
23	F. L. Churchill	Meals and board	4.00
25	S. Wakefield	Services	6.00
	Haas Bros	Photo work	1.68
	John E. Dempsey	Tablets	6.72
	A. D. Brooks & Co	Supplies	15.43
26	Beckfelt & Mather	Groceries	125.96
	Wm. H. Ames	Services	26.10
30	Sundry persons	Pay roll for June	764.25
	Robinson & Cary Co	Gauge glasses	.36
	Total		26,090.65

Outstanding liabilities June 30, 1896.

To whom owing.	On account of—	Amount.
Sundry persons	Pay roll for June	$450.00
Do	do	140.00
Do	do	80.00
Do	do	962.50
Do	do	145.46
Do	do	298.98
F. S. Bonness	Telephone poles	97.50
Beckfelt & Mather	Mess supplies	52.82
W. J. & H. D. Powers	Hardware	25.33
Do	do	20.14
A. P. White	Lumber	24.80
Lewis Wilson	Use of horse	13.00
Frank N. Allen	do	7.00
John O'Brien	Services	2.00
William Nelson	Hay	6.00
Joseph Crowther	Transportation	14.00
Do	do	12.01
Cross Lake Logging Co	Beef, etc	3.60
St. Paul Hardware Co	Hardware	4.95
Northern Pacific R. R. Co	Ticket	11.12
St. Paul and Duluth R. R. Co	do	4.14
Boeringer & Son	Repair work	17.15
Griggs Bros	Empty sacks	75.00
Do	do	22.50
Slipp Bros	Hardware	60.53
D. M. Clark & Co	Twine, etc	8.10
Northern Pacific Express Co	Express charges	20.00
Do	do	10.30
Zimmerman Bros	Photo supplies	7.67
Wm. B. Hale & Co	Battery, etc	1.75
Duluth and Winnipeg R. R. Co	Rental	15.00
James A. Quigg	Meals and lodging	2.25
George Snetsinger	Traveling expenses	26.75
H. H. Perrine	do	8.10
A. O. Powell	do	10.70
Slipp Bros	Hardware	5.50
Line & Brooks	Bags	7.00
S. & J. W. Koop	Sacks	14.00
Cross Lake Logging Co	Labor, etc	657.28
A. T. Kimball	Hauling	5.00
Archibald Johnson	Traveling expenses	22.91
James Walsh	Services	6.00
Freeman Dolan	do	6.00
Archie Purdy	Team hire	30.50
St. Paul Foundry Co	Pig iron	150.00
Wm. Gordon	Freight	.75
A. C. Gould	Messenger, etc	7.25
John Jackson	Services	17.50
Western Union Telegraph Co	Telegrams	2.08
Do	do	5.21
North American Telegraph Co	do	2.02
Lieut. Col. W. A. Jones	Mileage	17.56
Northern Pacific R. R. Co	Tickets	8.24
Freight accounts (estimated)		1,063.50
H. Drapeau	Sacks	18.60
Total outstanding		4,708.05
Expended to June 30, 1896		26,090.65
Total		30,798.70

Y 3.

IMPROVEMENT OF CHIPPEWA RIVER, INCLUDING YELLOW BANKS, WISCONSIN.

The first examinations and surveys of this stream were made in 1874 and 1875. Based upon the latter, a project was prepared for the improvement, consisting of the revetment of caving banks and construction of dams and jetties from Eau Claire to the confluence of the stream with the Mississippi River, a distance of 56 miles, in order to confine the low-water volume to a channel of nearly uniform width; also to protect the five Yellow Banks bordering on the river. Object: To provide an open channel 200 feet wide and 3 feet deep, and relieve

the channel of the Chippewa River and of the Mississippi River below the junction of the two streams from the sand contributed by the Yellow Banks. First estimate of cost, $139,892.50. The project has remained unaltered, except an increase in the amount of work to be done. The estimate has been revised three times. The last one (made in 1888) placed the cost at $272,487.72.

Before the improvement commenced the depth on the bars at low water seldom exceeded 18 inches, and the crossing at the mouth of the river was extremely difficult at that stage, owing to the volume of the river joining the Mississippi through a number of channels of insufficient depth. Frequently the depth of water on the bar at the mouth of the river was but 10 or 12 inches.

The work of improvement to June 30, 1895, has provided a permanent channel 3 feet deep over the bar at the mouth of the river, and materially increased the depths over the Durand, Plum Island, Plum Island Flats, Battle Island, Wacouta Island, and Flower Pot Island bars, besides straightening a difficult piece of river at the Madison Street Bridge in Eau Claire, and the stoppage of a difficult and dangerous cut-off at Dead Lake. Where the improvements have been completed, the channels are 3 feet or more in depth. The channel improvements have effected a material reduction in the cost of running rafted lumber from Eau Claire to the mouth of the river.

No work of consequence has been done at the Yellow Banks since 1883, at which time about one-fifth of the banks had been revetted.

Total expended from commencement of operations in 1877 to June 30, 1895, including outstanding liabilities, $175,150.39.

Operations during the past fiscal year.—Repairs were made to Plum Island Dam No. 3 and to the East Jetty at mouth of river. Wacouta Island Dams Nos. 2 and 3 were built to assist Wacouta Island Dam No. 1 in preventing a diversion of part of the water to the left side of Twin and Wacouta islands.

The following statement shows the cost of work during the past year:

Care of property, outfit, repairs to plant, superintendence, and St. Paul office expenses		$2,600.56
Repairs, Plum Island Dam No. 3:		
Labor, picking up 11 cords stone from rocky shore	$22.00	
Labor, placing 11 cords stone and 46 1 1/2 3/8 cords brush	75.25	
		97.25
Building Wacouta Island Dams Nos. 2 and 3:		
46 cords stone, at $3.85	177.10	
54 cords stone, at $3.50	189.00	
553.7 cords brush, at $1.14½	633.99	
Labor, placing 140 cords stone and 553.7 cords brush	756.37	
		1,756.46
Repairs, East Jetty:		
Inspection	30.00	
68⅛ cords brush, in place, at $2.40	163.50	
205 cords stone, in place, at $4.75	973.75	
		1,167.25
Total		5,621.52

Distribution of material on hand June 30, 1895:

Repairs, Plum Island Dam No. 3, 46 1 1/2 3/8 cords brush, at $1.84	$86.15
Building Wacouta Island Dams Nos. 2 and 3, 40 cords stone, at $4.50	180.00
Total	266.15

No material on hand June 30, 1896.

Mr. A. O. Powell, assistant engineer, has had local charge of the improvement of the river, as well as of the St. Croix River, in addition

to duties as assistant engineer on all the works pertaining to this district.

Expenses during the fiscal year ending June 30, 1896, including outstanding liabilities, $5,621.52.

The sum of $80,737.72 can be profitably expended during the fiscal year ending June 30, 1898:

For channel improvements	$70,737.72
For survey	10,000.00
Total	80,737.72

This work is in the collection district of Milwaukee, Wis. The duties on imports collected during the year ending December 31, 1895, amounted to $390,504.99.

Abstract of appropriations.

By act—		By act—	
Approved August 14, 1876	$10,000	Of August 11, 1886	$10,000
Approved June 8, 1878	10,000	Approved September 19, 1890	10,000
Approved March 2, 1879	8,000	Approved July 13, 1892	5,000
Approved June 14, 1880	10,000	Of August 17, 1894	10,000
Approved March 3, 1881	10,000	Passed June 3, 1896	10,000
Passed August 2, 1882	65,000		
Approved July 5, 1884	15,000	Total	191,750
Approved August 5, 1886	18,750		

Money statement.

July 1, 1895, balance unexpended		$6,962.23
Amount appropriated by act of June 3, 1896		10,000.00
		16,962.23
June 30, 1896, amount expended during fiscal year		5,959.14
July 1, 1896, balance unexpended		11,003.09
July 1, 1896, outstanding liabilities		25.00
July 1, 1896, balance available		10,978.09
Amount (estimated) required for completion of existing project		80,737.72
Amount that can be profitably expended in fiscal year ending June 30, 1898		80,737.72

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

Comparative statement of lumber, laths, shingles, pickets and logs for eighteen years.

Year.	Lumber.	Laths.	Shingles.	Pickets.	Total tonnage exclusive of loose logs.	Loose logs.
	Feet, B. M.	*Number.*	*Number.*	*Number.*	*Tons.*	*Feet, B. M.*
1878	154,119,860	40,000,000	125,000,000	10,000,000	.....	Unknown.
1879	248,932,000	62,044,000	135,152,000	12,000,000	.....	250,000,000
1880	325,150,000	100,357,750	74,945,150	2,423,940	.....	300,000,000
1881	342,887,000	64,787,000	121,437,000	1,880,000	.....	300,000,000
1882	375,000,000	66,000,000	150,000,000	2,200,000	.....	350,000,000
1883	269,094,203	82,643,500	129,754,000	1,497,948	.....	450,000,000
1884	298,344,591	88,905,520	160,133,000	1,840,278	.....	534,674,176
1885	374,138,443	95,992,900	195,880,220	75,000,000	.....	600,000,000
1886	207,205,672	77,729,630	158,465,750	1,934,340	.....	465,000,000
1887	186,826,521	64,725,580	130,516,200	3,023,235	.....	404,302,650
1888	161,309,512	50,544,370	86,348,900	1,500,320	325,971	542,437,000
1889	158,938,294	50,487,355	112,053,075	2,244,786	329,156	400,518,720
1890	166,477,966	46,234,673	78,499,500	1,222,989	342,350	606,992,790
1891	152,040,386	107,841,850	48,700,210	1,258,850	314,085	284,113,430
1892	144,651,150	46,451,170	109,356,000	1,507,050	410,960	632,350,670
1893	159,180,534	43,938,210	108,774,500	1,940,525	459,505	488,926,000
1894	128,703,908	33,550,370	74,183,250	1,420,618	333,157	250,045,730
1895	130,117,213	29,928,099	69,718,000	581,705	327,550	292,640,000

Comparative statement of freight and passengers for eighteen years.

Year.	Steamboats.	Freight carried.	Passengers.	Year.	Steamboats.	Freight carried.	Passengers.
		Pounds.				*Pounds.*	
1878	4	Unknown.	Unknown.	1882	3	2,640,000	10,490
1879	4	6,840,000	8,730	1883	3	3,184,000	4,000
1880	4	3,440,000	11,240	1884	2	1,500,000	5,500
1881	3	3,932,000	16,989	1885 to 1895	*1		

* One hundred and eight tons burden and 2 feet draft.

But one steamboat plied regularly on the river during the past eleven seasons. This boat, the *Phil Sheckel* (108 tons burden and 2 feet draft), ran from the mouth to Dunnville, about halfway between the mouth and Eau Claire, to assist the Knapp, Stout & Co. company's rafts in floating down the river. Her passengers and freight were confined entirely to the company's rafting business.

Y 4.

IMPROVEMENT OF ST. CROIX RIVER, WISCONSIN AND MINNESOTA.

The project for improvement contemplates removal of snags, bowlders, bars, etc., and the contraction of the low-water channel from Taylors Falls to the head of Lake St. Croix, also widening and straightening the channel where it is narrow or tortuous in Lake St. Croix, to furnish an open channel 3 feet deep from Taylors Falls to the Mississippi River, 52.3 miles.

The original estimate of cost ($21,758) was made in January, 1875, and based upon a survey made in 1874 when the St. Croix was at a high stage of water. A low-water survey was made in 1879. The present estimate of cost is $126,700.

The lower part of the river is known as Lake St. Croix. Stillwater, at the head of the lake, divides the navigable portion of the river into two sections, the upper or river section, 28.5 miles in length, and the lower or lake section, 23.8 miles in length.

The original channel above Stillwater was encumbered by sunken cribs, wrecks, snags, and old boom piers, and the bends by leaning trees. The depth on many of the bars was but 2 feet. The free navigation of the lower section was obstructed by partly sunken logs and by the Hudson and Catfish bars, 6.3 and 15.1 miles, respectively, below Stillwater. The channel over the Hudson Bar was quite tortuous and shallow, having but 2.5 feet depth at low water. At Catfish the channel had sufficient depth, but made a sharp bend around a long narrow sand spit that jutted out for a distance of 1,450 feet from the left bank and at right angles to the shore line. When a strong wind blew up or down the lake, the steamboat with heavy rafts encountered considerable difficulty in keeping the channel.

The improvements to June 30, 1891, resulted in a decidedly improved channel above Stillwater to the advantage of the river traffic then existing. The improvements consisted in the removal of sunken cribs, wrecks, snags, old boom piers, and leaning trees, and the construction of wing dams to contract the channel over the worst bars, and thereby increase the depth over the bars worked on from an original low-water depth of 2 to 3 feet, though the full object of the improvement was not

attained. Since 1886 the railroads penetrating the region have reduced navigation over this section to almost nothing, except the running of loose logs; as a consequence, little attention during the past eight years has been given to its improvement.

On the lower section (Stillwater to the mouth) the commerce, consisting of rafted lumber and logs towed by steamboats, is of large proportions and its needs are being met by expending the largest part of appropriations on this reach. By June 30, 1895, channels had been dredged through the Catfish and Hudson bars to a depth of 4 feet at low water and the water directed into new channels by training dams. Many of the partly submerged logs, were also removed but new ones are continually coming into the channel. The work has resulted in creating a fair steamboat channel, 4 feet deep at low water, from Stillwater to the mouth. Boats and rafts can now pass over that distance at the lowest stage, but some work remains to be done in widening the dredged channels and straightening other portions, particularly on the Hudson Bar above and below the bridge, and in the construction of additional training dams to maintain the dredged channels.

Amount expended to June 30, 1895, including outstanding liabilities, $111,066.43.

On account of lack of funds, no work of improvement was undertaken during the past fiscal year. The property was cared for, considerable office work done in preparation for future work, and a survey made of the head of Lake St. Croix for the purpose of formulating a plan of improvement. A map* of the head of the lake is submitted herewith.

Total expended during fiscal year ending June 30, 1896, including outstanding liabilities, $1,405.34.

This work is in the collection district of Minnesota, of which St. Paul is the port of entry and St. Vincent a subport. Collections for the year ending December 31, 1895, $320,760.20; value of domestic exports for same period, $172,968.

Abstract of appropriations.

By act—		By act—	
Approved June 18, 1878	$10,000	Of August 11, 1888.....	$10,000
Approved March 3, 1879	8,000	Approved September 19, 1890	8,000
Approved June 14, 1880	10,000	Approved July 13, 1892	8,000
Approved March 3, 1881	8,000	Of August 17, 1894	4,000
Passed August 2, 1882	30,000	Passed June 3, 1896	15,000
Approved July 5, 1884	9,000		
Approved August 5, 1886 ...	7,500	Total	127,500

Money statement.

July 1, 1895, balance unexpended.....	$3,384.70
Amount appropriated by act of June 3, 1896.....	15,000.00
	18,384.70
June 30, 1896, amount expended during fiscal year	3,348.07
July 1, 1896, balance unexpended.....	15,036.63
July 1, 1896, outstanding liabilities	8.40
July 1, 1896, balance available.....	15,028.23

* Not printed.

COMMERCIAL STATISTICS.

Comparative statement of steamboats and barges, freight and passengers carried, and lumber and logs towed and rafted on the St. Croix River, Wisconsin and Minnesota, for a period of eighteen years.

STEAMBOATS AND BARGES.

Year.	Freight and passenger business.		Steamboats in towing and rafting business.	Year.	Freight and passenger business.		Steamboats in towing and rafting business.
	Steamboats.	Barges.			Steamboats.	Barges.	
1878	3	.....	8	1887	3	40	58
1879	3	.....	12	1888	1	3	58
1880	3	.....	29	1889	1	1	52
1881	2	.....	40	1890	*2	3	126
1882	3	24	77	1891	1	.....	†130
1883	3	25	51	1892	.....	.....	†122
1884	3	25	30	1893	.....	.....	†127
1885	4	33	50	1894	*1	2	†69
1886	6	38	49	1895	.....	.....	(‡)

* One hundred and seventeen tons burden and 18 inches draft.
† From 35 to 240 tons burden and 2½ to 3½ feet draft.
‡ Unknown.

FREIGHT AND PASSENGERS.

Year.	Freight carried.			Passengers carried.	Year.	Freight carried.			Passengers carried.
	Lumber.	Wood.	Total.			Lumber.	Wood.	Total.	
	Tons.	*Tons.*	*Tons.*			*Tons.*	*Tons.*	*Tons.*	
1878	(*)	(*)	16,000	15,000	1886	(*)	(*)	90,450	12,756
1879	(*)	(*)	23,893	9,244	1887	(*)	(*)	28,500	9,872
1880	(*)	(*)	(*)	(*)	1888	5,200	4,354	90,554	(*)
1881	(*)	(*)	17,500	11,015	1889	5,900	4,100	10,000	(*)
1882	(*)	(*)	30,000	10,300	1890	7,139	5,796	†13,144	921
1883	(*)	(*)	31,500	12,800	1891	100	200	300	551
1884	(*)	(*)	40,000	4,000	1894	3,205	(‡)	3,205	(‡)
1885	(*)	(*)	42,500	10,647	1895	(‡)	(‡)	(‡)	(‡)

* Unknown. † Including 209 tons of general merchandise. ‡ None.

RAFTED LOGS AND LUMBER.

Year.	Rafted logs towed out of St. Croix River (estimated).	Rafted lumber towed out of St. Croix River.				Total tonnage, exclusive of loose logs.	Loose logs run on river above Stillwater.	
		Lumber.	Shingles.	Laths.	Pickets.		Feet, B. M.	Tons.
	Feet, B. M.	*Feet, B. M.*	*Number.*	*Number.*	*Number.*	*Tons.*		
1878	70,000,000	.....	.....	.....	.....	.....	.....	.....
1879	117,000,000	.....	.....	.....	.....	.....	.....	.....
1880	200,000,000	.....	.....	.....	.....	.....	.....	.....
1881	185,000,000	.....	.....	.....	.....	.....	.....	.....
1882	130,000,000	.....	.....	.....	.....	.....	.....	.....
1883	108,000,000	.....	.....	.....	.....	.....	.....	.....
1884	175,000,000	.....	.....	.....	.....	.....	.....	.....
1885	150,000,000	.....	.....	.....	.....	.....	.....	.....
1886	115,000,000	.....	.....	.....	.....	.....	.....	.....
1887	175,000,000	*100,000,000	.....	.....	.....	.....	.....	.....
1888	136,000,000	114,610,966	*40,079,500	*23,651,800	*570,820	*706,367	.....	.....
1889	150,000,000	81,817,070	38,633,000	23,226,575	90,800	697,244	.....	.....
1890	250,000,000	116,403,000	46,007,000	33,861,900	278,580	1,104,100	*460,000,000	*1,610,000
1891	209,233,490	110,934,084	32,016,750	31,132,350	678,240	948,757	315,231,300	1,103,310
1892	250,000,000	126,503,520	51,959,000	37,387,200	261,040	1,179,549	436,899,770	1,529,149
1893	160,000,000	63,564,209	23,196,500	18,413,720	118,580	707,745	359,468,740	1,358,141
1894	150,000,000	105,912,803	38,861,250	28,385,600	1,059,420	805,838	281,470,400	985,146
1895	213,000,000	133,893,315	22,521,250	33,733,935	340,095	1,021,884	373,062,850	1,305,720

* Unknown previous years.

Y 5.

IMPROVEMENT OF MINNESOTA RIVER, MINNESOTA.

An examination of this stream was made in 1866, and surveys in 1872, 1874, and 1887.

The first examination called forth two projects and estimates:

Original estimates, Yellow Medicine to the mouth, 237 miles, Annual Report, 1867:

(1) Removal of snags and bowlders and the construction of a lock and dam at Little Rapids, to afford a channel 2 to 3 feet deep.....	$117,000
(2) Construction of locks and dams to afford a channel 4 feet deep.....	775,500

The channel plan (1) was approved by Congress in appropriating $37,500 March 2, 1867, for "removing snags and bowders."

Following the survey of 1874, the following project was adopted in 1875 for improving the river from South Bend to the mouth, 116.4 miles, Annual Report, 1875:

Construction of locks and dams to provide slack-water navigation with a channel 4 feet deep.....	$733,868.63
Amount previously appropriated.....	87,500.00
Total.....	821,368.63

Other estimates have been made, but were not accepted for projects. For a recital of the various estimates and more full history of the river reference is made to the Annual Reports for 1894 and 1895.

The appropriations to 1878, inclusive, aggregate $117,500, and were expended between 1867 and 1879 in surveys and the removal of snags, overhanging trees, and bowlders. The reach worked over extended from Minnesota Falls to a point 9.9 miles above Carver. The work was done to temporarily facilitate high-water navigation, of which in an early day and before the advent of railroads there was a considerable volume. Since 1879 new snags have appeared in such numbers that there are now as many as at any previous time; therefore it can not be said that any permanent improvement was effected.

No work was done on the river between 1879 and 1893, and at no time has Congress authorized the improvement of the river upon the basis of the present approved project—a canalization of the river. After railroads penetrated the Minnesota Valley the navigation of the river practically ceased.

Within the past few years a demand has arisen for the low-water improvement of the lower 24 miles of the river—Shakopee to the mouth. Previous to the fall of 1893 no money had been spent on the lower part of the river, which presents a marked contrast to the upper section.

Below Shakopee the river is, in the main, very deep, almost free from snags and caving banks, and would offer exceptional advantages to the navigation thereof were communication between it and the Mississippi River rendered permanent by the improvement at the mouth of the river.

In the fall of 1893 a project was entered into for the improvement of the river below Chaska and Shakopee by building a closing dam at the foot of Pike Island and across the main channel at the mouth of the river and diverting the river during low stages into a channel dredged through the Fort Snelling Chute. For a fuller description of the plan of improvement see pages 1726 and 1727, Annual Report, 1894.

By the close of the last fiscal year the closing dam had been built to the height of low water at head of Pike Island and a temporary channel excavated through the Fort Snelling Chute. The project, if

carried out to permanent completion, gives promise of attaining the object sought.

Amount expended to June 30, 1895, on project for improvement at mouth of river, $10,000.

Total amount expended to June 30, 1894, on all parts of the river, $127,500.

There was no money available for work during the past fiscal year.

Abstract of appropriations.

By act—		By act—	
Approved March 3, 1867	$37,500	Approved August 14, 1876	$10,000
Approved July 11, 1870	10,000	Approved June 18, 1878	10,000
Approved March 3, 1871	10,000	Of August 11, 1888	10,000
Approved June 10, 1872	10,000	Passed June 3, 1896	4,000
Passed March 3, 1873	10,000		
Approved June 23, 1874	10,000	Total	131,500
Approved March 3, 1875	10,000		

Money statement.

July 1, 1895, balance unexpended	$491.87
Amount appropriated by act of June 3, 1896	4,000.00
	4,491.87
June 30, 1896, amount expended during fiscal year	491.87
July 1, 1896, balance unexpended	4,000.00
Amount (estimated) required for completion of existing project	689,868.63
Amount that can be profitably expended in fiscal year ending June 30, 1898	11,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

COMMERCIAL STATISTICS.

	Steamboats plying on lower part of river.			Freight carried.					
	No.	Tonnage.	Draft.	Wheat.	Hay.	Wood.	Brick.	Miscellaneous.	Total.
		Tons.	*Inches.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1888	1	.....	.....	.....	.....	.....	.....	.....	3,350
1889	2	153 180	18 20	.....	.....	.....	.....	.....	4,900
1890	3	117 153 180	18 30 20	62	809	840	1,080	842¼	3,633¼

There was no traffic on the river during the seasons of 1891, 1892, 1893, 1894, and 1895, as steamboats could not at all times pass the bar at the mouth of the river.

Y 6.

IMPROVEMENT OF THE RED RIVER OF THE NORTH, MINNESOTA AND NORTH DAKOTA.

The project for improvement of this river from Breckenridge to the northern boundary line, adopted in 1877, consists in the removal of snags, leaning trees, and bowlders, and in dredging channels through the bars, except at Goose Rapids, where a lock and dam were proposed. The estimated cost was—

For the open-channel improvement, exclusive of Goose Rapids	$145,310.18
For lock and dam, Goose Rapids	219,287.99
Total	364,598.17

In 1883 the cost of the open-channel improvement, exclusive of Goose Rapids, was revised and placed at $179,310.18.

Until August 5, 1886, the improvement of the river exclusive of Goose Rapids and the improvement of Goose Rapids were considered as separate works.

In 1886–87 they were consolidated into one, and the project for the improvement of the river was modified by substituting the open-channel methods (removal of bowlders and dredging) over Goose Rapids for the proposed lock and dam. In 1887 the cost of completing the improvement was estimated at $79,598.37, making the total cost of the improvement from commencement of work $252,598.37. In 1893 this was increased to $67,320 for completion, or for total cost from commencement of work, $310,320.

Previous to the passage of the river and harbor act of June 3, 1896 the object of the improvement was to provide an open channel from Breckenridge to the northern boundary line, 395.5 miles, as follows:

(1) Breckenridge to Moorehead, 97 miles. A channel capable of being navigated during high and medium stages of water.

(2) Moorehead to Grand Forks, 155 miles. A channel 60 feet wide and 3 feet deep at low water.

(3) Grand Forks to the northern boundary line, 143.5 miles. A channel 60 feet wide and 4 feet deep at low water.

The current bill contained the item:

Improving Red River of the North, Minnesota, and its tributaries: continuing improvement, twenty thousand dollars, of which sum five thousand dollars, or so much thereof as may be necessary, shall be used in improving the navigation of the Red Lake River between Thief River Falls and Red Lake, according to the plan of Major W. A. Jones in his report of February twenty-sixth, eighteen hundred and ninety-five.

Congress has thus extended the object to be attained to improving a portion of the Red Lake River and has increased the estimate by $5,000, or a total of $315,320.

In 1879, when the first bar was dredged through, the ruling depth at ordinary low water between Moorhead and Goose Rapids has been stated to have been but 1.5 feet, and below Grand Forks but 2 feet.

The dredging work to June 30, 1895, resulted in the attainment of the object on the second division except for 13 miles at Goose Rapids, and the attainment of the object on the third division except for redredging bars which formed during the spring of 1895. The bars or slides on the third division occurred after the required depth and width had been obtained.

The river is subject to landslides. These slides, which can never be anticipated, form obstructions when they occur, and have to be removed in whole or in part, thereby increasing the cost of improvement.

The removal of snags and trees between Moorhead and Abercrombie improved that section of the stream for navigation during high and medium stages of water.

Expended upon the improvement from the commencement of the work in 1877 to June 30, 1895, including outstanding liabilities, $253,089.90.

OPERATIONS DURING THE FISCAL YEAR ENDING JUNE 30, 1896.

Redredging in the third division, necessitated by the landslides referred to above, commenced in the spring of 1895, was continued and completed the last of July, 1895, resulting in again opening the river from Grand Forks north to the boundary line.

Dredging in detail for past fiscal year.

Number of cut,	Location.	Excavation.	Channel cut.	Training dams.
		Cu. yds.	*Lin. ft.*	*Lin. ft.*
12	Sec. 1, T. 156, R. 51	1,675	800	800
13	do	800	350	350
14	Sec. 31, T. 157, R. 51	975	400	400
15	Sec. 17, T. 156, R. 51	750	300	300
16	Sec. 18, T. 156, R. 51	450	225	225
Total		4,650	2,075	2,075

Cost of subsistence per ration, 38.5 cents. Average cost of dredge excavation, 17.5 cents per cubic yard. The cost of operating the steamboat is included in the general cost of the work.

The total work done on this stream since the first appropriation for its improvement was made in 1876, extending from Fort Abercrombie north to the boundary line, a total river distance of 395.5 miles, is as follows:

Material dredged	cubic yards	787,485
Snags removed		665
Bowlders removed	cubic yards	431¼
Overhanging trees removed		8,752
Stumps removed		198
Piles removed		23
Drift piles (collection of driftwood, snags, etc.)		8
Barge removed		1
Channel excavated	linear feet	160,209
Wing and training dams constructed	do	205,855

On the portion of the river worked over and maintained by the dredges the average depth of the channel has been increased from 1.5 to 2 feet.

All of the work for the improvement of this stream has been performed by hired labor.

Expended upon this improvement during the fiscal year ending June 30, 1896, including outstanding liabilities, $4,372.13.

Abstract of appropriations.

By act—		By act—	
Approved August 14, 1876	$10,000	Of August 11, 1888	$20,000
Approved June 18, 1878	30,000	Approved September 19, 1890	25,000
Approved March 3, 1879	25,000	Approved July 13, 1892	25,000
Approved June 14, 1880	20,000	Of August 17, 1894	15,000
Approved March 3, 1881	18,000	Passed June 3, 1896	20,000
Passed August 2, 1882	10,000		
Approved July 5, 1884	10,000	Total	278,000
Approved August 5, 1886	50,000		

Money statement.

July 1, 1895, balance unexpended	$6,204.29
Amount appropriated by act of June 3, 1896	20,000.00
	26,204.29
June 30, 1896, amount expended during fiscal year	5,666.32
July 1, 1896, balance unexpended	20,537.97
Amount (estimated) required for completion of existing project	37,320.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	37,320.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS.

The stage of water during the season of 1895 was below the general average, but on the improved portion navigation was always possible. The range at the Grand Forks gauge was only 6.4 feet (from +5.1 feet April 5 to —1.3 feet November 8). The usual spring flood did not occur. Steamboat navigation commenced April 18 and closed October 23. The river was clear of ice from April 7 to November 20.

The Red River Transportation Company during the winter of 1894–95 rebuilt their fleet, consisting of one steamboat, *Grand Forks*, 100 tons, and three barges of about 127 tons each.

A gasoline boat, *City of Grand Forks*, built in 1894, with two barges of about 40 tons each, was engaged in the movement of freight in 1895 for the first time.

Following is a statement of the freight moved by boats during the season of 1895.

Red River Transportation Company's steamer *Grand Forks* and three barges:		
To Grand Forks, N. Dak., from north and south:		
Wheat	tons..	8,615
To Grand Forks, from north:		
Merchandise	do...	9
Lumber	do...	52
City of Grand Forks, gasoline boat, and two barges:		
To Grand Forks, from the south:		
Wheat	do...	421
To Grand Forks, from the north:		
Wood	do...	315
From Grand Forks, south:		
Merchandise	do...	1
Total freight moved	do...	9,413

Comparative statement of freight moved by steamboats and barges during the past seventeen years.

Year.	Tons.	Year.	Tons.	Year.	Tons.
1895	9,413	1889	3,866	1883	25,314
1894	7,684	1888	12,140	1882	31,652
1893	5,723	1887	10,405	1881	26,557
1892	14,256	1886	10,507	1880	21,651
1891	12,137	1885	23,045	1879	17,829
1890	1,710	1884	29,046		

Y 7.

GAUGING MISSISSIPPI RIVER AT OR NEAR ST. PAUL, MINNESOTA.

The Board of Engineers, to whom was referred the project for the application of $37,500 appropriated by the river and harbor act of August 5, 1886, for reservoirs at the head waters of the Mississippi River, recommended in their report dated May 24, 1887, "that such gaugings be made at or near St. Paul during the annual operation of the reservoirs as shall determine accurately the discharge at that point at critical periods." (Annual Report Chief of Engineers, 1887, p. 1692.)

The river and harbor act of August 11, 1888, authorized the gaugings, but none were made until the fall of 1889, although an allotment of $900 for the fiscal year ending June 30, 1889, had been made. The sum was not expended on account of the lateness of the season and the condition of the river.

For the purpose of preserving a concise record of the volume of the Mississippi River at St. Paul, all gaugings made at that point by this office during the past year are included in the list below.

Table of gaugings made at St. Paul, Minn., during the fiscal year ending June 30, 1896.

[Location: Above Robert Street Bridge. Observer: David Wallace. Method: Herschel current meter No. 13.]

No.	Date.	Reading of Signal Service gauge, St. Paul.	Discharge per second.	Remarks.	No.	Date.	Reading of Signal Service gauge, St. Paul.	Discharge per second.	Remarks.
	1895.		*Cu. feet.*			1895.		*Cu. feet.*	
1	July 6	3.12	6,564		13	July 25	1.80	4,620	
2	July 8	3	6,596		14	July 26	1.77	4,604	
3	July 9	3.07	6,549		15	July 27	1.77	4,722	Wind downstream.
4	July 11	2.77	6,195	Wind downstream.	16	July 29	1.57	4,396	Wind upstream.
5	July 12	2.67	5,848						
6	July 13	2.52	5,716		17	July 30	1.72	4,761	
7	July 15	2.40	5,722	Do.	18	July 31	1.47	4,046	
8	July 16	2.35	5,709		19	Aug. 1	1.40	3,986	
9	July 17	2.27	5,459		20	Aug. 2	1.27	3,759	Wind downstream.
10	July 20	2.30	5,330						
11	July 22	1.87	4,885		21	Aug. 3	.97	3,410	
12	July 24	1.80	4,820		22	Aug. 5	.82	3,302	

[Method: Ellis current meter No. 21.]

	1895.		*Cu. feet.*			1895.		*Cu. feet.*	
23	Aug. 6	1.1	3,747		51	Sept. 11	1.95	4,959	
24	Aug. 7	.77	3,230		52	Sept. 12	2	4,875	
25	Aug. 8	.90	3,418		53	Sept. 13	1.90	4,391	Wind upstream.
26	Aug. 9	1.02	3,488						
27	Aug. 10	1.32	3,987		54	Sept. 14	1.75	4,412	
28	Aug. 12	1.79	4,782		55	Sept. 16	1.55	4,354	
29	Aug. 13	1.82	4,677		56	Sept. 17	1.80	4,499	
30	Aug. 14	1.95	5,032		57	Sept. 18	1.60	4,053	
31	Aug. 15	2.12	5,174		58	Sept. 19	1.75	4,352	
32	Aug. 16	1.95	4,912		59	Sept. 21	1.80	4,232	
33	Aug. 17	2.02	5,075		60	Sept. 23	2.45	5,332	Wind downstream.
34	Aug. 19	1.99	4,909						
35	Aug. 20	2.05	5,086		61	Sept. 24	2.40	5,425	
36	Aug. 21	1.90	4,856		62	Sept. 25	2.32	5,114	
37	Aug. 23	1.68	4,569		63	Sept. 29	2.20	5,044	
38	Aug. 24	1.74	4,582		64	Sept. 30	2.20	5,037	
39	Aug. 26	1.81	4,871		65	Oct. 1	2.30	5,188	
40	Aug. 27	1.80	4,553		66	Oct. 2	1.98	4,814	
41	Aug. 29	1.75	4,444		67	Oct. 4	2.15	5,064	
42	Aug. 30	1.66	4,155		68	Oct. 5	2.10	5,028	
43	Aug. 31	1.67	4,109		69	Oct. 7	2.02	4,893	
44	Sept. 3	1.7	4,109		70	Oct. 8	2.12	5,110	
45	Sept. 4	1.7	4,139		71	Oct. 9	2.10	5,045	
46	Sept. 5	1.77	4,175		72	Oct. 10	2.10	4,808	
47	Sept. 6	1.77	4,262	Wind downstream.	73	Oct. 11	1.92	4,482	
					74	Oct. 12	2	4,826	
48	Sept. 7	1.90	4,477		75	Oct. 14	1.80	4,381	
49	Sept. 9	1.85	4,670		76	Oct. 15	1.90	4,651	
50	Sept. 10	2	4,452						

[Observer: Kent Nelson. Method: Ellis current meter No. 21.]

	1896.		*Cu. feet.*			1896.		*Cu. feet.*	
77	Apr. 4	.86	3,400		82	Apr. 10	1.89	5,019	
78	Apr. 6	1.38	4,244		83	Apr. 11	2.20	5,389	Water rough.
79	Apr. 7	1.57	4,131	Side wind.	84	Apr. 13	4.20	9,601	
80	Apr. 8	1.78	4,294	Wind upstream.	85	Apr. 15	8.58	20,045	Wind downstream.
81	Apr. 9	1.72	4,494	Wind downstream.	86	Apr. 16	9.71	29,583	
					87	Apr. 17	10.51	33,902	Water rough.

Table of gaugings made at St. Paul, Minn., etc.—Continued.

[Method: Ellis current meter No. 18.]

No.	Date.	Reading of Signal Service gauge, St. Paul.	Discharge per second.	Remarks.	No.	Date.	Reading of Signal Service gauge, St. Paul.	Discharge per second.	Remarks.
	1896.		*Cu. feet.*			1896.		*Cu. feet.*	
88	Apr. 20	9.80	30,505		110	May 29	9.49	28,423	
89	Apr. 21	9.37	27,832		111	June 1	9	26,036	Wind up-stream.
90	Apr. 22	8.95	25,801	Wind down-stream.	112	June 3	8.40	23,832	
					113	June 4	8.16	21,929	Do.
91	Apr. 24	8.13	21,643	Do.	114	June 5	7.91	21,448	
92	May 1	7.97	22,234		115	June 6	7.64	20,102	
93	May 2	8.35	23,769		116	June 12	8.86	26,034	Wind down-stream.
94	May 4	8.96	25,820						
95	May 5	9.13	26,920		117	June 13	8.88	24,878	
96	May 6	9.23	26,866	Do.	118	June 16	7.98	21,459	
97	May 7	9.20	26,965	Do.	119	June 17	7.57	20,636	
98	May 8	9.13	26,210	Do.	120	June 18	7.21	18,232	Wind up-stream.
99	May 9	8.98	25,497	Do.					
100	May 11	8.60	22,853	Side wind.	121	June 19	6.89	17,358	Do.
101	May 12	8.40	22,705	Wind down-stream.	122	June 20	6.60	*16,160	
					123	June 21	6.32	*14,864	
102	May 15	8.41	22,623	Do.	124	June 22	6.07	*14,480	
103	May 18	9.60	28,543	Wind up-stream.	125	June 23	6.23	*14,592	
					126	June 24	6.42	*15,852	
104	May 19	10.01	30,507		127	June 25	6.71	16,497	Wind down-stream.
105	May 20	10.31	31,167						
106	May 22	10.50	32,590		128	June 26	6.72	16,576	Do.
107	May 26	9.65	29,138		129	June 27	6.81	16,881	Do.
108	May 27	9.52	28,345		130	June 29	6.18	*14,136	
109	May 28	9.52	28,133						

*When the signal service gauge reads 4.65 and upward, water passes over a closing dam on the west side of island where gauging station is located. Between stages of 4.65 and 6.70 it is impracticable to measure with the meter the volume passing on west side of island, as the current is too sluggish. To arrive at the quantity flowing on that side, the measurement for the gauge readings 10.50 to 6.71 were platted and the curve extended to zero volume at stage 4.65.

The location of the gauging sections is shown on the map* herewith. The gaugings were made by observing the mid-depth velocities in sections 20 feet apart. The mean velocity was taken as 95 per cent of the mid-depth velocity. The manner of making the volume measurement is clearly presented on the accompanying photographs.* The boat is held in position by two employees who grasp wire ropes stretched across the river 13 feet apart. The upper line is tagged every 10 feet. A sounding is taken opposite each tag and a current observation at the alternate tags. The wire ropes are run out before and reeled up after each gauging.

The plate* herewith and the two plates published in the report for 1895 show the effect of the reservoir water upon the Mississippi River at St. Paul during the low-water periods of the years 1893, 1894, and 1895. The three records indicate that a rise in the river at St. Paul commences in 7 or 8 days following the release of water from the distributing reservoir at Pokegama Falls, and in about 5 days thereafter the full effect is felt. The mean time is therefore 10 days. The rise on the signal-service gauge, St. Paul, due to reservoir water in 1893 was 1 foot; in 1894, 1.3 feet; in 1895, 1.2 feet.

The gaugings made during the years 1894 and 1895, supplemented by the gauge readings and the diagram published opposite page 1734,

* Not printed.

Appendix Z, Annual Report for 1894, are sufficient for a close determination of the total discharge.

Relation of run-off to rainfall on the watershed of the Mississippi River above St. Paul, Minn., years 1894 and 1895.

[Area of watershed, 36,081 square miles.]

Year.	Rainfall.					Total rainfall.	
	2.	3.	4.	5.	6.	7.	8.
	Mean at Leech Lake, Lake Winnibigoshish, and Pokegama Falls dams.	At St. Paul, Minn.	At Morris, Minn.	Assumed mean over drainage area.	Total since Jan. 1, 1894.	By calendar years.	Since Jan. 1, 1894.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Cubic feet.*	*Cubic feet.*
1894	26.63	25.80	18.22	23.55	23.55	1,974,040,580,160	1,974,040,580,160
1895	25.11	24.26	16.77	22.05	45.60	1,848,305,511,360	3,822,346,091,520

Year.	Run-off.		Average volume of river per second.		Proportion of run-off to rainfall.		Average volume of run-off per second per square mile.	
	9.	10.	11.	12.	13.	14.	15.	16.
	By calendar years.	Since Jan. 1, 1894.	By calendar years.	Since Jan. 1, 1894.	By calendar years.	Since Jan. 1, 1894.	By calendar years.	Since Jan. 1, 1894.
	Cubic feet.	*Cubic feet.*	*Cu. ft.*	*Cu. ft.*	*Per ct.*	*Per ct.*	*Cu. ft.*	*Cu. ft.*
1894	227,515,289,600	227,515,289,600	7,215	7,215	11.53	11.53	0.200	0.200
1895	123,358,457,600	350,873,747,200	3,912	5,563	6.67	9.18	0.108	0.154

The assumed mean rainfall over drainage area may be in error, though it is believed to be as correct an approximation as existing records will furnish. The position of the rainfall record stations may be seen on the map submitted with the report on reservoirs at head waters of Mississippi River. The drainage area above St. Paul contains two distinct meteorological basins, drained respectively by the Minnesota River and the Mississippi River above the mouth of the Minnesota. The depth of rainfall on the former is less than on the latter, and the ratio of run-off to rainfall for the two areas is correspondingly different. The ratio for the Minnesota River is undoubtedly considerably less than the figures given in the table for the combined basins, and for the Mississippi River above the Minnesota the ratio is unquestionably greater.

The relation of run-off to rainfall on the watershed of the Mississippi River above Pokegama Falls Reservoir Dam for the years 1885–1895, inclusive, is given in the report on operating and care of reservoirs at head waters of Mississippi River.

The gaugings and computations pertaining thereto have been made under the supervision of Asst. Engineer Archibald O. Powell.

Amount expended during fiscal year ending June 30, 1896, $500.

Abstract of allotments.

For fiscal year ending June 30—		For fiscal year ending June 30—	
1889	*$900.00	1894	$500.00
1890	600.00	1895	500.00
1891	900.00	1896	500.00
1892	900.00	1897	500.00
1893	500.00		

* Not used.

Money statement.

Amount allotted for fiscal year ending June 30, 1896	$500
Amount allotted for fiscal year ending June 30, 1897	500
	1,000
June 30, 1896, amount expended during fiscal year	500
July 1, 1896, balance unexpended	500

Itemized statement of expenditures during the fiscal year ending June 30, 1896.

Date.	To whom paid.	For what paid.	Amount.
1895.			
Aug. 23	D. W. Collies	Skiff	$10.00
31	A. O. Powell	Services	180.00
Sept. 11	W. D. Hale & Co	Dry battery, etc	1.65
14	Boeringer & Son	Repair work	.75
Oct. 1	A. O. Powell	Services	90.00
29	....do	....do	90.00
	Robinson & Cary Co	Clips	.64
Nov. 11	Albert Nelson	Services	1.50
14	American Express Co	Express charges	.90
	W. B. Hale & Co	Dry battery	.75
	Ryan Drug Co	Sponges, etc	1.25
	W. B. Smith	Repair work	1.00
1896.			
Jan. 6	Robinson & Cary Co	Wire rope	34.00
Mar. 7	John E. Dempsey	Blanks	3.00
Apr. 22	M. S. Kennedy & Bros	Oars	1.60
28	Robinson & Cary Co	Clips	1.20
May 30	Sundry persons	Pay roll for May, 1896	81.00
June 11	Boeringer & Son	Repair work	.76
	Total		500.00

Y 8.

SURVEYS FOR RESERVOIRS AT THE SOURCES OF MISSISSIPPI, ST. CROIX, CHIPPEWA, AND WISCONSIN RIVERS.

Nothing was done under this head during the past fiscal year, no funds having been available for such work. For account in detail of these surveys reference is made to pages 1507 and 1508, Appendix Y, Part III, Annual Report of the Chief of Engineers, 1886.

It has been demonstrated that the reservoir system at the sources of the Mississippi River increases the navigable capacity of the Mississippi River at St. Paul at least 1 foot during low-water seasons. It is simply a question of more or less water collected as to whether the improvement shall be more or less than that. More water must of necessity improve a river for navigable purposes, and hence I think it advisable to see whether the great collecting capacity of the watershed of the Crow Wing River can not be added to the present supply at a reasonable cost. It is therefore recommended that the sum of $5,000 be expended in making an examination and survey of the basin of Crow Wing River with a view to determine whether its waters can be added to the reservoir system at a reasonable cost.

It is to be particularly noted that although the steamboat navigation above Minneapolis is at present insignificant, the time is pretty sure to come when it will be important; and, furthermore, there is to-day an enormous commerce upon these waters. The great mass of floating logs is nothing more or less than a commercial product being moved to market by the cheapest known form of transportation. The actual annual tonnage of products of the forest thus moved to market is considerably in excess of 1,000,000 tons, and the tonnage is rapidly increasing.

This is a commerce worthy of attention and consideration.

Money statement.

Amount (estimated) required for completion of existing project.....	$50,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	5,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

Y 9.

SURVEY OF CHIPPEWA RIVER, WISCONSIN.

[Printed in House Doc. No. 245, Fifty-fourth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., February 12, 1896.

SIR: The river and harbor act of August 17, 1894, provides, in the item making appropriation for the improvement of Chippewa River, Wisconsin, for a survey of said river for 2 miles south of the Dells Dam, and I have now the honor to submit the accompanying copy of report, dated February 4, 1896, with map,* by Lieut. Col. W. A. Jones, Corps of Engineers, upon the subject.

Colonel Jones states that he is unable to discover any necessity for improving this part of the Chippewa River and no plans or estimates of cost are submitted.

Very respectfully, your obedient servant,

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

Hon. DANIEL S. LAMONT,
Secretary of War.

REPORT OF LIEUT. COL. W. A. JONES, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., February 4, 1896.

GENERAL: I have the honor to forward herewith a tracing of map of survey of Chippewa River, Wisconsin, for 2 miles south of the Dells Dam, made under provision of the act of Congress of August 17, 1894.

I have not been able to discover any object in the way of improving the river for purposes of navigation for which this survey was ordered. There is no navigation, present or prospective, over the reach covered by the survey except that of floating logs and a limited number of rafts of manufactured lumber from the mill above the Madison Street Bridge. The channel is sufficient for these latter purposes.

* * * * * * *

Very respectfully, your obedient servant,

W. A. JONES,
Lieut. Col., Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

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* Omitted. Printed in House Doc. No. 245, Fifty-fourth Congress, first session.

APPENDIX Z.

IMPROVEMENT OF MISSOURI RIVER AT AND ABOVE SIOUX CITY, IOWA, AND OF YELLOWSTONE RIVER, MONTANA AND NORTH DAKOTA.

REPORT OF LIEUT. COL. W. A. JONES, CORPS OF ENGINEERS, OFFICER IN TEMPORARY CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Missouri River between Stubbs Ferry, Mont., and lower limits of Sioux City, Iowa.
2. Removal of snags and other obstructions in Missouri River, above Sioux City, Iowa.
3. Yellowstone River, Montana and North Dakota.

UNITED STATES ENGINEER OFFICE,
Sioux City, Iowa, July 15, 1896.

GENERAL: I have the honor to transmit herewith reports upon the works of this district for the year ending June 30, 1896.

Very respectfully, your obedient servant,

W. A. JONES,
Lieut. Col., Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

Z 1.

IMPROVEMENT OF UPPER MISSOURI RIVER BETWEEN STUBBS FERRY, IN MONTANA, AND THE LOWER LIMITS OF SIOUX CITY, IOWA.

Prior to August 17, 1894, the improvement of the Upper Missouri River was confined to the distance of 1,480 miles lying between Sioux City and Fort Benton. By the river and harbor act of the above date the limits of improvement were extended to include the distance of 180 miles lying between Fort Benton and Stubbs Ferry.

Between Stubbs Ferry and Great Falls, in Montana.—The distance between Great Falls and Stubbs Ferry is 131 miles. The river is very rapid to the town of Cascade, 77 miles below Stubbs Ferry, falling in this distance about 287 feet. At the two greatest obstructions, Half Breed Rapids and Bear Tooth Shoal, the slope is nearly 10 feet to the mile. Over the whole 77 miles there is a constant succession of shoals and rapids. A small amount of work was done on this reach during 1880, from an allotment of the appropriation for improving the Missouri River above the mouth of the Yellowstone.

Commencing at a rapid just below Cascade and extending to the city of Great Falls, a distance of 54 miles, the fall is very gentle, being little over one-half foot to the mile. A depth of 3 feet can be carried over the whole distance, except at the six bars included in the present project for improvement.

The original project was submitted January 23, 1892, by Capt. Chas. F. Powell and approved. It contemplated the removal of the rocks in the rapids above Cascade and the contraction of the channel both above and below by closing chutes in the rear of islands by dams, and contraction of the river channel by spur dikes or wing dams. This project was modified November 30, 1894, only as to cost, however, the original estimate, $115,000, being increased to $165,000; a new survey having been made, which showed shoals not indicated on the original examination.

The present project, adopted November 30, 1894, is as follows:

Snagging between Great Falls and Cascade	$200.00
Dams and dikes between Great Falls and Cascade	63,975.00
Bank protection between Great Falls and Cascade	17,500.00
Dams and dikes between Cascade and Stubbs Ferry	75,000.00
Removing rock between Cascade and Stubbs Ferry	9,040.00
Buoying rock between Cascade and Stubbs Ferry	97.50
Total	165,812.50

and contemplates the improvement of the reach of river from the city of Great Falls to Stubbs Ferry. The plan was to force the water through a channel of an average width of 400 feet and obtain a low-water depth of 3 feet. To accomplish this it was proposed to close the chutes with willow and rock dams and contract the channel by dikes of the same materials.

The improvement on this part of the river has been confined to the Long Pool, which extends from the city of Great Falls, 54 miles, to the town of Cascade.

Object.—To secure a depth of 3 feet over the shoal places at extreme low water. This will necessitate improvements at the following places:

Great Falls Island,
White Bear and Wickners islands,
Fox Island,
Wescott Island,
Griffins Bar, and
Thurmans Bar.

No work was done above the Great Falls between 1880 and 1894. A survey was made of the Missouri River from Stubbs Ferry to Great Falls, and during the former year 822 cubic yards of rock were taken out of Bear Tooth Rapids and 106 cubic yards from Half Breed Rapids. The amount expended was about $15,000.

At the end of the last fiscal year the obstruction at Great Falls Island had been removed, the chutes in the rear of White Bear and Wickners islands had been closed by dams, and spur dikes had been built out from the upper ends of White Bear and Wickners islands to contract the low-water channel.

The amount expended thereon to close of fiscal year ending June 30, 1895, was $9,164.90, from allotment of $20,000 in the river and harbor act of August 17, 1894.

The river over which this project extends is paralleled by the Montana Central Railroad, yet if the river could be made to have a depth of 3 feet at extreme low water or 4.5 at ordinary low water, great quan-

tities of wool, grain, and hay would be carried over the river between Cascade and Great Falls.

During the past fiscal year the dam in the rear of Fox Island, in process of construction at the end of the last fiscal year, was completed and three spur dikes constructed in the bay opposite Fox Island. (See accompanying map.) Dams were also built closing the chutes behind Wescott and Willow islands.

The dikes and dams were built of brush and rock in alternate layers, the brush being bound into fascines from which mattresses were constructed.

The contraction of the channel at Fox Island has secured the desired depth. A survey made before the work was completed showed a depth of more than 3 feet over the bar at low water.

There was used in the work 714 cords of brush and 7,113 cubic yards of rock. The total expenditures during the last year have been $10,611.15.

The work was done by hire of labor and purchase of material, and was under the immediate charge of Mr. E. D. Vincent, assistant engineer, whose report is appended.

The results of the work of improvement up to June 30, 1896, have been to give the required depth of water to Wescott Island Shoal, a distance of 9 miles above Great Falls. Maps* accompanying this report show the locality of the improvement.

Great Falls to Benton.—This reach of about 40 miles is almost a continuous rapid, has a fall of nearly 550 feet, including the Great Falls, 90 feet, and the Rainbow Falls, about 50 feet sheer falls. No work has been done on this stretch of river, and none is projected.

Fort Benton to Carroll.—For this reach, known as the "Rocky River," covering 172 miles, the approved project contemplates the removal of bowlders and rocks from the rapids and the contraction of the channel by dikes and dams to make a deeper low-water channel. The estimated cost is $720,345.46. including the cost of the work done before the adoption of the present project.

Nothing has been done on this project during the year, as no navigation exists on this part of the river at the present time.

Before 1882, this stretch of river had a large commerce, as all or nearly all of the freight destined for Montana, Idaho, and the British possessions was distributed from Fort Benton. The completion of the Northern Pacific Railroad to Helena, Mont., took away more than one-half of this business, and when the Great Northern Railroad was completed to Helena, in 1887, navigation over this reach about ceased, except a few trips made up as far as Judith, Mont., in the two succeeding years to bring down wool from that point. Since 1890 no steamers have traded here.

From Carroll to Sioux City.—This reach covers a stretch of river of 1,308 miles. In addition to appropriations and allotments for ice harbors and river surveys, specific appropriations were made for the following places:

At Bismarck Harbor, North Dakota;
At Pierre and Fort Pierre, S. D.;
At Sioux City, Iowa,

and are reported under these heads, respectively. The removal of snags, etc., is a distinct work and a separate report is made thereon.

Rockhaven Ice Harbor.—During the year ending June 30, 1895, work

*Not printed.

on the harbor adjacent to the land that had been previously acquired by the Government was finished. Work on the remaining part of the projected harbor was commenced (the title to the land having been acquired) early in July.

On July 8 grading was started, and completed September 18. During this time a total of 32,054 cubic yards was removed of which a part was rock. The stone dike at the head of the harbor was built up from 15 to 23 feet above low water. A watchman's dwelling was also built, started in June, 1895, and described in last year's report.

Amount expended during fiscal year $16,371.83.

Sioux Ice Harbor.—This ice harbor is located on the Big Sioux River about a mile above its confluence with the Missouri. It is a strip of land 2,600 feet long and from 100 to 250 feet wide, bordering on the Sioux River on the Dakota side. The work of grading was commenced April 6 and completed May 2 of this year. In the middle of the tract an incline for hauling out boats was graded 500 feet long, with an easy slope of 1 on 7. The bank of the river along the rest of the slope was graded to a slope of 1 on 2, and the whole tract plowed, leveled, and seeded. It is proposed to plant on the bank 14 mooring posts, 175 feet apart, 8 feet long, set 6 feet in the ground and to be set in a block of concrete at the bottom, with a heavy concrete collar at the surface of the ground; these posts are constructed of five-eighth inch mild steel forming a cylinder 15 inches in diameter with a cast-iron cap. It is proposed to build a fence of woven wire around the whole tract.

The fence is at present under construction and the mooring posts have been contracted for with James Rees & Sons Co., of Pittsburg, Pa.

Amount expended during fiscal year $3,579.13.

River survey.—The project contemplated the completion of a detailed survey from Fort Benton, Mont., to Sioux City, Iowa.

Two series of maps are platted. The first or detail charts are lithographed and printed on scales 1:7200 for the 79 maps above the mouth of the Yellowstone River and of 1:12000 for the 119 charts from there to Sioux City. The second series are of a much smaller scale, viz, 1:31680 (2 inches to a mile), have no soundings platted on them, and the hills are represented by hachures, while on the detail charts they are represented by contour lines. The small scale series is not published.

The series of detail charts consists of 198 editions with 3 index charts; these had all been platted and drawn at the end of the last fiscal year and 181 of them published, leaving 17 detail charts and 3 index charts. These have been published during the year ending June 30, 1896. Of these Julius Bien & Co., of New York, have published 1 index chart, the Forbes Lithograph Manufacturing Company, of Boston, 10 detail charts and 2 index charts, and the Heliotype Printing Company of Boston, 7 detail charts.

Two index charts for the small scale series have also been platted and drawn this year, completing that series so that the whole survey may now be said to be completed.

Amount expended during fiscal year, $3,293.33.

At Bismarck Harbor.—By the river and harbor act of August 17, 1894, $40,000 was allotted to the "protection of Bismarck Harbor and the rectification of the river by works to prevent the river from eroding the bank and cutting a new channel at or near that point."

The project adopted contemplated the rectification of the river at and near Bismarck Harbor. Estimated cost, $40,000.

The work projected to be done with this sum was the construction of 8 spur dikes in a bay three-fourths of a mile above Bismarck Bridge,

where the bank was cutting badly, making it not improbable that the river would during some flood take an old channel immediately in the rear of the proposed work and through the town of Mandan into the Heart River, leaving the Bismarck Bridge and Bismarck Harbor inland. Seven of these dikes were completed when the funds were exhausted and the work suspended.

The dikes were built out nearly to the old shore line of 1891. Their lengths being as follows:

	Feet.		Feet.
No. 1	210	No. 5	560
No. 2	270	No. 6	570
No. 3	460	No. 7	380
No. 4	480		

The result obtained is the filling in of a sand bar between each of the dikes, and this too where the main channel of the river ran just before and during construction. Had the dikes all held, the object desired would have been completely attained, but the heavy run of ice during the break-up last March carried off the outer ends of some of them, as follows:

Nos. 1, 2, and 3 were but slightly injured;
No. 4 had about 40 feet carried off at the outer end;
Nos. 5 and 6 lost 160 feet each; and
No. 7 about 200 feet.

The damage was repaired temporarily during May to give the work the benefit of the deposit of material carried by the June rise, the temporary work being put in position so it can be made part of the permanent work of repair to be done hereafter.

There was used in this work 766 piles, driven to an average penetration of 22 feet, at a cost of $6,213.78. There was constructed 239,500 square feet of mattress, at a cost of $10,568.69, which was ballasted with 4,362 cubic yards of rock, at a cost, including material, of $10,112.19. The bracing and screening of the dikes, 4,550 linear feet, cost $3,893. The balance of the allotment was consumed in construction of new and repair of old plant, superintendence of work, grading of banks, and miscellaneous expenses pertaining to the construction. Maps showing location of works of improvement accompany this report.

The work was done by hired labor and the material was purchased in the manner authorized by law and was under the local charge of Mr. H. C. Gould, assistant engineer, whose report is herewith.

The river bed above and below spreads out in places to nearly a mile in width. The high water of the summer flood covers this whole extent and it is difficult to tell where the best channel will be at the subsidence of the flood.

Since 1891 it has been attacking the right bank $\frac{3}{4}$ of a mile above the Northern Pacific Bridge, and has cut into the bottom land more than 1,000 feet.

The amount expended thereon during the fiscal year ending June 30, 1895, was $6,496.43.

The extent of commerce here, as at all other points on the upper Missouri River is small and nothing but a general improvement of a long reach between important points will materially increase it. Confine the low-water channel of the river to a width of from 700 to 1,200 feet between Bismarck and Sioux City, then steamers will be able to compete with other modes of transportation, but the enormous cost, estimated at nearly $40,000 per mile, seems a large amount if appropriated in a lump sum, yet with the comparatively small amounts allotted

from year to year, works can be built in the line of a general-improvement project, and the money can be profitably expended.

The commerce to and from Bismarck during the year amounted to 10,727 tons of freight and 425 passengers. The value of the freight carried amounted in round numbers to over $100,000.

Amount expended during fiscal year, $28,795.24.

Pierre and Fort Pierre.—The river and harbor act of August 17, 1894, allotted $40,000 to the "rectification of the river at Pierre and Fort Pierre." The present project, adopted October 23, 1894, contemplates the expenditure of $40,000 for the rectification of a part of 7 miles of the river in this locality, at an estimate cost of $360,000. The projected works form a part of a scheme for the general rectification of the river, confining it to a channel width of 700 feet.

At the end of the last fiscal year the dam in the rear of Marion Island was about three-fourths completed. Work was continued on the dam at intervals until September 24, when it was completed. It consisted of a framed mattress 50 feet wide laid on the bottom of the river, extending across the chute from bank to bank. On this mattress was placed a crib of cottonwood 18 feet wide and 4 feet high, filled with rock, and then on top of this crib a similar one 13 feet wide and 4 feet high, and again a crib 8 feet wide and 4 feet high, forming a pyramidal dam reaching entirely across the chute and even with the adjacent banks in height. This dam has settled some since built, but has pretty effectively closed up the chute and accomplished the intended purpose.

The dikes at Fort Pierre, 5 in number, were built to stop a badly cutting bank. Their lengths are as follows:

	Feet.		Feet.
Dike 1	220	Dike 4	220
Dike 2	220	Dike 5	350
Dike 3	160		

The dikes consist of two rows of oak piles running out perpendicular to the shore line; the rows and piles in the rows are 10 feet apart. At the outer end of these two rows a T head is formed by driving two rows of piling 10 feet apart and with 7 piles in each row. The piles are protected from scour by a willow mattress 50 feet wide extending an equal distance above and below the rows of piles.

Work on the dikes at Fort Pierre was begun July 12, and completed September 24.

Dikes 1 and 2 at Pierre are, respectively, 540 and 280 feet in length, and were built between September 9 and October 10. Dike 2 was of the same construction as those at Fort Pierre, but Dike 1 was built of crib work similar to the dam in the rear of Marion Island. A map showing locality of dikes and dam is herewith.

The work was done by hired labor and purchase of part of the material in open market, and was in local charge of Mr. W. G. Price, assistant engineer, whose report is appended.

The lumber for construction of dike-building plant and of the dikes was purchased under contract with James H. Owen, of Pierre, S. Dak., approved January 3, 1895. Delivery commenced February 26 and completed July 26, 1895.

The stone used for sinking mattresses and dike construction was furnished and delivered between February 28 and August 13, 1895, under contract with Cyrus B. Ingham, approved January 22, 1895.

All the dikes at Pierre and Fort Pierre have caused sand bars to form above and below them as expected, and have stopped the banks from

cutting. They withstood the break-up well, only one pile having been carried away during the break-up of the ice in March.

The river at Pierre and Fort Pierre spreads out to so great a width, giving the water so much latitude immediately in front of Pierre, that at low water there is a navigable channel of little over 3 feet. Above and below the town the channel is good, but is liable to change. The project contemplates the contraction of the channel to a width of 700 feet for a distance of 7 miles by closing dams in the rear of La Framboise and Marion islands, and spur dikes at intervals along both shores. It is thought if this project is carried out a depth of from 6 to 8 feet will be given in the improved channel.

The amount expended on this work up to the close of the fiscal year ending June 30, 1895, was $16,952.21, mostly for plant and material, little work having been done on the dikes and dams.

The comparatively little accomplished toward a systematic rectification of the river over the distance named in the foregoing, has had little effect in improving the navigable channel way, as it forms but part of a project which will be effective only when complete. The work, however, has resulted in stopping badly-cutting banks and in confining and straightening the channel.

It is not thought that even if this project were carried out to completion it would materially increase the commerce of the river. There is no local commerce here now and none would result by making a deep channel for the short distance of 7 miles.

Amount expended during fiscal year, $22,081.07.

At Sioux City.—The project for the expenditure of $40,000 toward the rectification of 7 miles of river at Sioux City at an estimated cost of $400,000 was adopted April 13, 1895.

With the allotment of $40,000 from the sundry civil act of 1895, 16 dikes were constructed along the bluff at the upper end of the Sioux City front varying in length from 185 to 400 feet. The work was commenced after the June rise had begun to subside, on July 1. The construction and location of the dikes are shown in the accompanying drawings. They consist of a foot mat sunk and ballasted with about three-fourths of a cubic foot of broken stone to each square foot of mattress. Piles were then driven through the stone and mattress, and braced, waled, and screened.

In this work 835 piles were driven at a cost of $7,703.72; 2,584 cords of brush and 7,242 cubic yards of broken stone were used in the construction and ballasting of the mattresses.

In the dikes there were 282,240 square feet of mattress.

The cost of weaving the mattress, including the brush, was $9,874.77, and of ballasting same with broken stone, $12,372.92; the cost of screening, bracing, and waling was $2,153.47.

The brush cost delivered at the work on barges $1.60 per cord, and the broken stone $1.16 unloaded from cars.

The piles were furnished by the St. Paul Timber and Supply Company, of St. Paul, Minn.; The McLeod Lumber Company, of St. Louis, Mo., and by J. Massey & Gifford, of Poplar Bluffs, Mo. The work of driving piles was done by Goodrich & Robson, of Sioux City. All by purchase and hire in open market.

The dikes have proved stable. Only a few piles were carried out by the ice on the spring break-up, and before the next opening of the river they will be so fortified by the material that will settle around them during the summer high water as to be almost immovable.

During the high water of the spring and subsequent rises in the river sand bars were formed between all the dikes from 1 to 8 feet above low water where in some places there had been from 10 to 18 feet of water at the time the dikes were constructed. A map showing locality and mode of construction of dikes is herewith.

The work at Sioux City was in local charge of Mr. F. M. Towar, assistant engineer, whose report is appended.

Amount expended during fiscal year	$30,077.41
Total amount expended at all localities, including outstanding liabilities, during the fiscal year ending June 30, 1896	134,501.88

WORK REQUIRED.

Stubbs Ferry to Great Falls.—The present project, adopted November 30, 1894, calls for $165,812.50. Of this amount $20,000, appropriated by the river and harbor act of August 17, 1894, was expended, or nearly so, on the reach known as the Long Pool before June 30, 1896.

Of that whole sum, $83,137 would be expended between Stubbs Ferry and Cascade, a total distance of 77 miles. Here the river is very steep, with numerous rocky rapids over almost the entire reach.

The availability of this stretch of river for navigation and commerce to any considerable extent is doubtful.

The Long Pool, where operations have been carried on during the year ending June 30, 1896, is an entirely different reach of river, with a gentle slope and few rocks, navigation only being obstructed by shoal bars. To complete the project on this part of the river will require, in addition to the $20,000 already expended, $62,812.50.

It is recommended that the $20,000 appropriated by the river and harbor act of June 3, 1896, be expended on this part of the river, and estimated that the sum of $42,812.50 could be profitably expended during the year ending June 30, 1898.

Great Falls to Fort Benton.—No funds are asked for this reach.

Fort Benton to Carroll.—Work on this project has ceased. To complete the project will require the expenditure of $193,147.28. No funds are asked.

Carroll to Sioux City.—The funds available are sufficient to complete the Sioux Ice Harbor. Five thousand dollars annually is estimated for maintenance of the Rock Haven and Sioux ice harbors and will be required. For snagging it will require $50,000 annually to keep the three snag boats in commission during the season of navigation, and $10,000 for extraordinary repairs to hulls and machinery of snag boats in 1898.

During the year ending June 30, 1896, work was done at Bismarck Harbor, at Pierre and Fort Pierre, and at Sioux City.

The approved projects for these places are: For the rectification of river above and below Bismarck Harbor, for 7 miles near Pierre and Fort Pierre, and for 7 miles at Sioux City.

The river and harbor act of June 3, 1896, appropriated $40,000 for Bismarck Harbor; $50,000 for the rectification of the river at Pierre and Fort Pierre, and $50,000 for the protection and completion of the works at Sioux City.

It has been recommended that the above amounts be expended in continuing work during the year ending June 30, 1897, on the adopted projects, and it is estimated that like amounts can be profitably expended at the several places during the year ending June 30, 1898.

APPROPRIATIONS.

The appropriations and allotments, exclusive of those for snagging, for the upper Missouri River have been as follows:

1876	$20,000	1886	$60,000
1878	42,500	1888	200,000
1879	60,000	1890	300,000
1880	43,000	1892	150,000
1881	66,000	1894	110,000
1882	115,000	1895	40,000
1884	140,000	1896	285,000

In addition to the above amounts, about $60,000 from the appropriations for the survey of the river from Fort Benton to the mouth was spent on the part above Sioux City.

Money statement.

July 1, 1895, balance unexpended	$134,662.61
By transfer of Treasury certificate	5.99
Amount appropriated by act of June 3, 1896	285,000.00
	419,668.60
June 30, 1896, amount expended during fiscal year	117,673.63
July 1, 1896, balance unexpended	301,994.97
July 1, 1896, outstanding liabilities	16,828.25
July 1, 1896, balance available	285,166.72
Amount (estimated) required for completion of existing project:	
Great Falls to Stubbs Ferry	125,812.50
Fort Benton to Carroll	Indefinite.
Amount that can be profitably expended in fiscal year ending June 30, 1898	187,812.50
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

PLAN AND ESTIMATE FOR THE IMPROVEMENT OF THE NEBRASKA SIDE OF THE MISSOURI RIVER, OPPOSITE SIOUX CITY, IOWA.

[Printed in Senate Doc. No. 270, Fifty-fourth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., April 21, 1896.

SIR: Public Resolution No. 41, joint resolution approved April 18, 1896, provides that—

The Secretary of War is hereby directed to cause to be prepared and submit a plan and estimate for the improvement of the Nebraska side of the Missouri River, opposite Sioux City, Iowa, in accordance with the report of Capt. H. F. Hodges, Corps of Engineers, dated November sixteenth, eighteen hundred and ninety-four, and printed in House Executive Document Numbered Forty-eight, Fifty-third Congress, third session.

In compliance with the requirements of the above resolution I have the honor to submit the accompanying copy of report, dated March 25, 1896, with two maps, * by Lieut. Col. W. A. Jones, Corps of Engineers, now in charge of this district, which embodies the information called for.

Very respectfully, your obedient servant,

W. P. CRAIGHILL,
Brig. Gen., Chief of Engineers.

HON. DANIEL S. LAMONT,
Secretary of War.

* Omitted. Printed in Senate Doc. No. 270, Fifty-fourth Congress, first session.

REPORT OF LIEUT. COL. W. A. JONES, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., March 25, 1896.

GENERAL: In compliance with instructions contained in your indorsement on copy of Senate resolution of March 16, 1896, calling for plan and estimate for improvement of the Nebraska side of Missouri River opposite Sioux City, Iowa, I have the honor to submit plan and estimate accordingly. The plan is shown on two sheets of maps herewith. Completed works in the vicinity are shown in black, proposed works in red. They show the plan of Captain Hodges for improvement of both sides of the river. It consists of a system of spur dikes of piles and mattress foundations for rectification of the channel, and mattress revetment for bank protection. Captain Hodges reports an immediate necessity for protecting the bank at the point O for a distance of 4,500 feet, and the remainder not worthy of improvement at this time.

ESTIMATE.

4,500 linear feet mattress, at $10	$45,000
Contingencies	5,000
	50,000

Very respectfully, your obedient servant,

W. A. JONES,
Lieut. Col., Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

REPORT OF MR. E. D. VINCENT, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Sioux City, Iowa, January 29, 1896.

CAPTAIN: I have to submit the following report of the Missouri River improvement work on the reach extending from Stubbs Ferry to the Great Falls, under my charge, from July 1 to November 7, 1895.

The project for the reach immediately above the Great Falls, known as Long Pool, and extending to the town of Cascade, a distance or 53.8 miles, was the construction of a series of dams and dikes for closing the chutes in the rear of the islands and for narrowing the stream at places where its unobstructed width left little available depth, and thus causing the river to deepen itself.

The project is detailed in my report for the year ending June 30, 1895.

The construction work begun April 1 last, and by July 1 the Wickners and White Bear Island dams and dikes had been finished and the Fox Island Dam was about one-half completed. The latter was finished July 9 and is a three-row dike 318 feet long across the shallow chute from the right bank to the head of Fox Island, and intersecting and crossing the small Island No. 162 about mid-channel. The crest of the dam is 5 feet above the low-water mark of 1889.

Work was begun on the 10th of July on the center dike of the system on the bay opposite Fox Island. The river, which had reached its highest stage of the season on June 29 (that of 4.5 above the low-water mark of 1889), rapidly fell from that date, and with the beginning of the Fox Island Dike construction the improvement work was more or less embarrassed by the low stage of the water. It was impossible to get the loaded barges to the dam and dike sites without the use of a lighter.

The center of Fox Island Dike is 700 feet long, with a 100-foot T-head. It is a single-tier construction, with the exception of 80 feet immediately under the left bank, where a channel 18 feet deep was filled. The crest is 3 feet above low-water mark. This dike was finished July 31, and work on the upper one of the system started August 1. The latter was finished August 17. It is a two-tier dike, 555 feet long, with a 100-foot T-head. The crest is 2½ feet above the low-water mark of 1889.

Work was begun on the lower and last dike of the Fox Island system the 19th of August. This dike crosses and closes a lateral channel of the river immediately under the left bank, which is from 6 to 10 feet deep; consequently the first 200 feet

of the dike is of two and four tier construction, while the remainder is a single-tier work with a 100-foot T-head. The total length of this dike is 542 feet, with the crest 2½ feet above the low-water mark.

After the June rise and during the progress of the work in the vicinity of Fox Island a resurvey of the White Bear Island Bar was made to ascertain the resultant effect of closing the chute in its vicinity. This examination disclosed the fact that through this bar, which last season entirely obstructed the stream with an average depth of water over it of but 2.5 feet, a channel varying in width from 230 to 500 feet had been scoured, with a depth of water of from 3.2 to 9 feet at the extreme low-water stage of the river. As 3 feet at low water was the depth sought to be secured, the results shown were entirely satisfactory, and the indications are that the channel will continue to deepen at the flood stages of the river.

Work was completed on the project in the vicinity of Fox Island on September 5, and on the 6th the camp outfit, etc., was loaded on the barges and towed to Wescott Island, 3 miles above and 8½ miles from Great Falls, where the bars obstructing the channel had been surveyed and located the fall before.

Some difficulty was experienced on the way up in getting the fleet over the bars that intervened, but no serious delays were encountered, and the upper camp was established the same day the lower one was abandoned.

Work was commenced on the Wescott Island project the 7th of September, and on the dam closing the narrow chute in the rear of Willow Island No. 160. The channel at the dam side was from 4 to 6 feet deep. The dam is a two and four tier construction 168 feet long, with the crest 5 feet above low water. The rock was obtained from a bluff adjacent to the river opposite the lower end of the island; the willows from the island itself. This dam was finished the 17th of September.

The river having now become so low, it was found impossible, even with a lighter, to get the loaded barges down the chute to the dam site in the rear of Wescott Island, so the former mode of procedure in construction had to be abandoned in building the next dam. The tender which had been in commission during the season and had been used as towboat up to date was therefore returned to the owner and the barges laid up. There being stone convenient, but some distance back from the river, the question then was as to its cheapest transportation by land to the dam sites. The two means suggesting themselves were by teams or by track carrying dump cars. As team hauling from a distance is always expensive and unsatisfactory, I decided on the use of the track and cars, and the results were satisfactory, the dam proving the cheapest one constructed during the season. The rails were hired from the Great Falls Street Railway Company and the dump cars from a local contractor.

The outfit was loaded on a barge at Great Falls and towed to Wescott Island by the tender before being returned. Track was laid from a quarry 1,200 feet back from the right bank of the river to and across the dam. The track was down, and the work started on construction the 20th of September, the loaded cars running down by the force of gravity, the speed controlled by a brakeman, and a team being used to haul the empties back. Two teams of two cars each were run, and a switch being provided at the quarry, one train was always loading while the other went down and back. The quarry capacity of the car was 48 cubic feet of loose rock and the average run is 13 trains a day. The cars were arranged to dump on the sides and could be unloaded wherever the rock was required. By this arrangement the force on the dam was reduced to 6 men. The channel in the rear of Wescott Island is quite shallow, the deepest water being 2½ feet for 150 feet next to the right bank. About 300 feet of the channel was dry at the time the dam was built.

The dam is a two-tier construction 488 feet long, with the crest 5 feet above low water. The first tier was constructed ahead of the track, the latter being carried forward as a roadway was provided, and was removed as the second tier was brought back and the dam finished. The fascines were made on the island and hauled to the work with a team.

This construction was the one instance where material was purchased for the work, $25 being paid for the quarry privilege.

This dam was finished October 16, and construction work for the season was closed, the force being disbanded with the exception of 8 men. The tender was again rechartered, and the force remaining was employed in tearing up track and returning the outfit to Great Falls, and in putting the plant in shape for the winter.

WORK IN DETAIL.

Labor and subsistence.—The crew on the improvement work proper consisted of 36 men, all told, and were hired by the month at $30 and subsistence. The last part of the season the dam-building crew were given $35. The crew was subdivided into three divisions, viz, brush crew, rock-quarrying crew, and dam-building crew, with a foreman with each. Camp was established in the vicinity of the work, and consisted of six tents that had to be shipped from Sioux City, Iowa. One cook, with a helper, had charge of the culinary department.

Produce and provisions were purchased at Great Falls, invitations being issued from time to time for sealed bids, ten days' notice being given to dealers.

Below is a statement of cost of subsisting the crew for the season from April 1 to October 30, 1895:

Subsistence account		$2,303.13
Superintendence		175.00
Wages of cook and helper, 6½ months at $80		520.00
Wages of cook from October 15 to October 30		25.00
Coal consumed, 15¾ tons at $2.74		43.28
Total		3,066.41
Less provisions on hand		27.32
		3,030.09

Six thousand six hundred and fifty-eight days of 3 meals each cost 45.6 cents per day.

MAKING FASCINES.

In making fascines 8 men with foreman were employed. The fascines were 20 feet long and 1 foot in diameter, composed of willows choked into shape and bound from four to six times around with ties of No. 14 annealed wire.

Six men with two racks did the binding, the 3 others keeping them supplied with brush. The racks were movable affairs and were carried from place to place, the brush being bound where it fell and the fascines carried out.

There were 9,170 fascines made and loaded on barges by this crew during the season, an average of 6.1 to a man or 54.9 per day for the crew, reckoning thirty working days in a month. The brush was not first quality for fascines, and being scarce everything possible was used. The following is from the daybook of August 19, showing the work of this crew under very favorable circumstances: "Brush crew of 9 men thirteen days near Great Falls Island cut, bound and loaded on barges 1,085 fascines; averaging 33½ per day, or 103 per day deducting the time loading; 119 was the greatest number cut and bound in one day. This tract, which was covered with No. 1 willows, yielded 246 20-foot fascines to the acre."

There were 50 cords of poles used during the season and 1,103 cords of willows made into fascines, 8 20-foot fascines being considered a cord.

Cost of making fascines.

Superintendence	$408.00	
Labor	1,348.00	
Subsistence	748.13	
		$2,504.96
Annealed wire used, No. 14, 3,392 pounds, at 3.46¾ cents		117.62
Total		2,622.58
Towing, 37.4 per cent of $2,557.77		956.61
Total		3,579.19

	Each.	Per cord.
	Cents.	
Fascines, cut, bound, and loaded, cost	28.6	$2.29
Fascines, delivered at work, cost	10.4	.73
	39	3.12

Nothing was paid for the brush-cutting privilege.

QUARRYING ROCK.

The crew employed in quarrying rock consisted of 12 men with foreman. The rock used in construction in the vicinity of White Bear and Fox islands was obtained from a rock point on the left bank opposite the lower end of Fox Island. The material was sand and limestone of very good quality.

By filling out from the bank with spalls and waste a landing was soon formed, allowing the barges to be loaded directly from the quarry with wheel and hand barrows.

There were three men constantly employed drilling with 1⅛-inch hand and churn drills; the holes would be put in the face of the bluff 8 or 10 feet back and were put

down 14 to 18 feet; they were first sprung with dynamite and then loaded with from 8 to 20 kegs of powder; a blast generally threw down from 20 to 30 barges of stone. The loosened rock was reduced to the handling size with hammers, and those pieces too large to sledge were block-holed and shattered with dynamite. This crew under favorable conditions would get out and load 4 barges of rock a day; 12 cubic yards in the solid was a barge load.

Cost of quarrying rock.

Superintendence	$544.00	
Labor	2,257.00	
Subsistence	1,143.03	
		$3,944.03
Explosives		420.14
Miscellaneous expense		21.96
Total		4,386.13
Towing, 62.6 per cent of $2,557.77		1,601.16
Total		5,987.29
9,161 cubic yards of rock (calculated loose) cost quarried and loaded		.479
9,161 cubic yards to deliver at work		.175
Total		.654

TOWING.

The steamer *J. J. Hill* was chartered without crew for the season from Capt. J. D. Taylor, of Great Falls, Mont., and was put in commission as towboat March 29. She was a double-engine and twin-screw boat, 50 feet over all, and drawing 3 feet light. She gave very good service, although drawing more water than a towboat should working on that reach of the river.

Her crew consisted of a pilot, engineer, and lineman. The two barges built for rock were 12 by 50 feet, and each carried about 30 tons. The two brush boats were 8 by 30, and would carry about 35 fascines; they were found to be entirely too small, however, for long hauls, and the latter part of the season were used to a great extent as lighters, the mattress boat, 9 by 47, which had been stripped of spuds and rigging, being used for brush, carrying about 90 fascines, and towing fully as easily as the smaller boats.

Coal for fuel was stored at Great Falls, and the tender would make trips down after hours for its supply, usually about once a week.

The boat would consume about six-tenths of a ton a day.

Detailed statement of the cost of towing.

Operating tender:		
Superintendence	$142.66	
Wages of crew	930.00	
Subsistence of crew	290.56	
		$1,363.22
Rent of tender		737.47
Coal consumed, 117¼ tons, at $2.75		322.31
Repairs of boat		98.86
Oil and waste		35.91
Total		2,557.77

DAM BUILDING.

The method pursued in building dams is detailed in my report for the year ending June 30, 1895.

Cost of laying and covering 20-foot mattresses:

Superintendence	$515.00	
Labor	1,603.24	
Subsistence	711.50	
		$2,829.74
Annealed wire, No. 12, 3,392 pounds, at 3.46¾ cents		117.63
Miscellaneous expense		15.00
Total		2,962.37

Nine thousand and five linear feet of 20-foot mattresses laid and covered cost 32.9 cents per linear foot.

Statement of the cost of the plant used in the improvement work on the reach above Great Falls, season of 1895–1896.

Boat building, etc.:		
Superintendence	$350.00	
Labor	683.36	
Total	1,033.36	
Lumber, 21,235 feet B. M., at $16.70 per M	448.37	
Hardware, etc	125.92	
Coal, 2 tons, at $3.60	7.20	
Total	1,614.85	
Barge purchased outright	25.00	
Rowboat purchased	10.00	
		$1,649.85
Tools		334.45
Camp equipage:		
Tents	156.00	
Kitchen utensils	65.75	
		221.75
Office furniture		13.80
		2,219.85

Statement of the cost of surveys and platting of obstructions in the reach above the Great Falls, season of 1895.

Pay rolls	$1,064.33
Subsistence	52.65
Office rent	75.00
Rowboats hired	45.00
Sundries	2.00
Total	1,238.98

Statement of the cost of removing piers at Great Falls Island, season of 1895.

Superintendence	$48.31
Labor	186.94
Rent of derrick	12.00
Total	247.25

On July 16 the tender struck a submerged bowlder in the channel off the head of Fox Island, and upon investigation there were found a number of them lying on the bar. They were resting upon a thin layer of gravel on top of a deposit of blue clay.

When the construction work at Wescott Island was suspended, the force remaining was taken to Fox Island, and the bowlders to the number of 40 were removed. They were mostly flat pieces of sandstone, varying from 1 foot in diameter to one-third of a cubic yard in solid contents. They were taken out by the aid of chains and hand grabs, the latter being built of 2 by 4 pieces made in the shape of forceps and about 6 feet long, the jaws being reenforced by iron bands. A bowlder of 200 pounds weight could be lifted with these grabs, and when one was found too large to handle, it was first shattered with dynamite. The work of removal was carried forward from a barge anchored in midstream. The rock taken out was deposited about the heads of the dikes.

A resurvey was made at the same time of the Fox Island Bar to note the effect, if any, of the scour across it, since the channel had been contracted by the system of dikes recently constructed in that vicinity. While there was a new channel found to be working through the bar, it was still narrow and crooked and in places lacked about one-half foot of the required depth of 3 feet at extreme low water. This place, however, had not had the advantage of a rise in the river since the improvement work was finished; but from indications it would appear that the bar will open from the scour during the next June rise and should develop a channel fully as complete as the one through the White Bear Island next below.

A survey was also made and maps drawn of the Goodrich Bar, located three-fourths of a mile above Fox Island. This bar, which had a comparatively free channel across it in the fall of 1894, was found to have entirely closed the river after the June rise in 1895.

The channel at this point is from 800 to 1,100 feet wide, and is unobstructed by islands, with the exception of a low bar in the middle of the stream, which rises a

few inches above the water at an ordinary stage. This bar divides the river into two nearly equal channels, neither of which carries sufficient water for successful navigation at a low stage. The one on the right, or along the east bank, is the more favorable for opening of the two. This channel is entirely obstructed for about 600 feet, the depth being about 2 feet at extreme low water. The material in the bar is sand.

Rock is convenient along the east bank, which also has a gravelly beach. Willows for fascines are scarce in the immediate vicinity of the bar. The rock removal and the surveys occupied the time from October 19 to the end of the month.

Field work was entirely suspended the 30th of October, and the plant was stored for the winter with a watchman in charge. The barges were left in the water in the chute back of Willow Island, and the camp equipage, etc., stored under shed room on the left bank of the river, opposite Wescott Island.

Very respectfully, your obedient servant,

EDWIN D. VINCENT,
Assistant Engineer.

Capt. H. F. HODGES,
Corps of Engineers, U. S. A.

Detailed description of dams and dikes constructed in the Long Pool above the Great Falls, season of 1895–96.

Dam or dike.	Total length.	Crest above low water, 1889.	Amount of dam or dike by tiers.					Total of 20-foot mattress laid and covered.
			Row 1.	Row 2.	Row 3.	Row 4.	Row 5.	
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Lin. feet.*
Wickners Island Dam	430	4	.....	260	30	.....	140	1,310
Wickners Island Dike	180	2½	280	.....	.....	.....	.....	280
White Bear Island Dam and Dike	545	5	.....	295	320	.....	.....	1,550
Fox Island Dam	318	5	30	58	230	.....	.....	836
Fox Island Dike No. 1	542	2½	405	100	.....	135	.....	1,145
Fox Island Dike No. 2	700	3	705	20	.....	.....	65	1,070
Fox Island Dike No. 3	555	2½	.....	619	.....	.....	.....	1,237
Willow Island Dam	168	5	.....	100	.....	68	.....	472
Wescott Island Dam	488	5	.....	359	129	.....	.....	1,105
Total	3,926	.....	1,420	1,811	709	203	205	9,005

Dam or dike.	Material used.			Cost of mattress laid and covered.	Total cost.
	Wire No. 12 and 14.	Brush and poles.	Rock, calculated loose.		
	Pounds.	*Cords.*	*Cubic yards.*		
Wickners Island Dam	982	185.2	1,303	$1.483	$1,942.52
Wickners Island Dike	210	47.2	342.4	1.483	415.21
White Bear Island Dam and Dike	1,161	194.1	1,660.7	1.483	2,298.40
Fox Island Dam	665	97.6	846.5	1.483	1,239.68
Fox Island Dike No. 1	858	143	948.8	1.483	1,697.86
Fox Island Dike No. 2	302	133.4	1,180.3	1.483	1,586.65
Fox Island Dike No. 3	927	152	1,027.1	1.483	1,834.28
Willow Island Dam	352	48	503.2	1.483	699.92
Wescott Island Dam	828	152	1,349	1.27	*1,402.52
Total	6,785	1,152.5	9,161	.....	13,117.04

* Willow fascines stored, 43.6 cords.

REPORT OF MR. H. C. GOULD, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Sioux City, Iowa, December 15, 1895.

CAPTAIN: I have the honor to submit the following report of operations to this date, since July 1, 1895, on protection of harbor at Bismarck, N. Dak., and completion of ice harbor at Rockhaven, N. Dak.:

BISMARCK HARBOR PROTECTION.

At the beginning of the year the plant for the work was practically finished, most of the material received, and construction just started at the upper end.

The form of dike and mattress is the same as that adopted for Pierre, S. Dak., and described in last year's report of that work. Their location is shown on the map herewith.

Dike No. 1.—Two more mooring piles were driven July 3. Mattress building on the ways were started July 1, and the last mat in No. 1 was placed July 10; weighting of the mattress was finished July 15. Driving of the dike piles was started on the 13th and finished on the 18th. The waling and screening was done between October 3 and 12.

The mattress was built on ways in sections 50 feet long and 50 feet wide, this being the width of the mattress in stem of the dike. The ways were laid on an incline of one on four, graded in the bank about 300 feet above Dike No. 1. The sections were pushed off the ways, floated to place in the dike, and securely wired to the next preceding section. The T-head mat was usually built in two sections, each 60 by 70 feet, floated into place, and wired to adjoining sections. Rock for weighting the mattress was brought from the railroad company's pile on ordinary railroad flat cars rented for the purpose, over the supply track to a temporary platform built to height of the car near shore end of the dike. It was then loaded on wheelbarrows, wheeled down the incline, over barges, and dumped directly on the mat.

Dike No. 2.—Five mooring piles were driven July 6 and 7. A switch track 600 feet long from the main supply track and the unloading platform were built July 10, 11, and 14.

Mattress work was started July 11 and finished July 16. Weighting the mattress was finished July 22. Driving of dike piles was done between July 20 and 26. Waling and screening was commenced October 5 and finished October 10.

The methods of work were the same as at No. 1.

Dike No. 3.—The grading at shore end had been done in June by the hydraulic method, using pump and hose of the snag boat *Josephine*, while her engineers were setting up the pile-driver machinery.

A siding 1,100 feet long and the platform for unloading rock were built between July 20 and 24.

The mattress building was started July 16 and finished July 26, this crew being engaged part of the time on other work. Weighting the mattress was finished July 31.

As this dike was considerably longer than previous ones, the rock was not wheeled all the way out, but the outer part was rocked by loading the rock on barges and swinging them out to where needed.

The pile driving was started near outer end July 27, endeavoring to get the piles driven across a shoal, but only the T-head could be driven. Piling between the bar and shore was finished August 5, leaving a space of 149 feet where the piles were driven with a land driver, which was built in September mostly from material and outfit on hand. This driver was set up and the piles on the bar were driven between September 16 to 23 and October 1 to 8. The line from the drop hammer and the pile line was run to the engine on the floating driver, which was moored to the T-head piles.

The waling and screening was mostly done between September 13 to 24 and October 7 to 11. Nearly all of the T-head had to be screened again, as the mat settled so far from the first poles put on.

The falling river developed a crossing of the main channel, which struck the sand bar just above No. 3, cutting it away and causing the T-head mat, part of which was on dry bar, to settle down into the water 6 to 12 feet; this settling of the T-head mat, aided by the position of the adjoining stem mattress, appeared to stop the cutting and deflected the current.

On account of bars and shoal water, the mattress building ways above Dike No. 1 were moved to a similar grade in the bank between Dikes 3 and 4.

Dike No. 4.—The grading at shore end was done between July 18 and 23.

A siding, 450 feet long, and the unloading platform were put in August 5 to 9.

Mattress building was commenced July 27 and suspended August 2; resumed August 22 and finished August 27. Weighting the mattress was done from July 27 to August 8, by wheeling from the rock pile into the mattress, after measuring in arranged piles, as the rock supply was near the shore end at first. The distance to wheel increased so much that from August 26 to 31 weighting was finished by loading cars and barges, as at preceding dikes. The barges had to be moved so far from shore and the current was so swift that it was found advisable to employ the small towboat *Imelda*, the only one in the vicinity, for this purpose part of the time.

The pile driving was done between August 5 to 12 and August 29 to September 2.

Waling and screening was commenced August 10, suspended August 24, and finished between September 17 to 20.

When the dike was built out 330 feet, shoal water was reached and work was suspended to see if the water would deepen beyond the end, but not much scouring occurred, and the dike was finished as noted above.

Dike No. 5.—The shore end was graded between July 27 and August 5.

Mattress building was started on the shore incline August 3; a high downstream wind during the night caused the water to cut away the slope under the partly finished mat, so that it was necessary to take it all out, regrade the slope, and build the mat over again.

The main current of the river was close to shore here, very swift, and depth of water 22 feet. The bank had been caving in all the time, the cut since April amounting to 93 feet. The mattresses were built stronger and in smaller sections, but in spite of precautions one of the mooring piles was pulled over by the current while sinking the mattress and a portion 135 feet long and partly rocked swung diagonally across the axis of the dike; after an attempt to pull it back into place it was sunk where it was and new mattress built to replace it in the dike line. Extra mats were also put in above and below the regular dike mattress, and all cutting of the bank was stopped. The mattress was continued out about half the length of the dike and stopped temporarily August 21, as the depth beyond was not enough to float the driver after mattress was down.

After the piles were driven the mattress building was resumed August 31. Ways and planks had been arranged on two of the large barges; the mattress was built on these in sections, 50 to 60 feet long, the barges and planks pulled from under the mattress, dropping it to the water, and then the boats moved forward to the next position. Near the T-head the water was too shoal to float the barges, so a large part was built by the men wading in the water; mattress work was completed September 13.

Weighting the mattress was finished September 19 and usually followed closely on its building; it was placed by wheeling from the rock pile into the mat, by loading barges which were towed by the *Imelda*, and the outer end had to be reached by wheeling out from shore over plank laid on the dike timbers.

The pile driving was done August 22 to 28.

The waling and screening was done between August 26 to September 12 and September 19 to 20.

Dike No. 6.—The grading at shore end was done from August 30 to September 5.

Some mattress was built and floated to place at shore August 28 to 30, and the rest of the mattress was built on the barges after piling was driven, between September 13 and 25. The weighting was done from September 7 to 9, and September 19 to 27, mostly by loading on barges which were handled by lines.

Pile driving was done between September 2 to 5, September 13 to 16, and the T-head was driven September 23 and 24. Shoal water caused considerable delay.

Waling and screening was started September 20 and finished October 5, except on grade at shore end, and which was done October 14.

Dike No. 7.—The shore end of this dike is on the heavy riprap work done by the railroad company.

Mattress building was started September 27 and finished October 10, all made on the barge ways except over shoal near outer end, where much of it was built by the men wading in water.

The mattress weighting was done from September 28 to October 15. The rock for outer part had to be loaded on barges, swung over to the bar, then wheeled out on the mattress.

The mooring piles were driven September 5 and 7, and the remainder of the piles were put in between October 8 and 14. For about 90 feet from where the deepest and swiftest water on the whole work was met some holes were 30 feet deep, but were filled up to 26 feet when mattress was down.

A few 42-foot piles (the longest we had) were spliced to about 60 feet long by squaring the head of the pile and an end of a short piece, butting them together, and spiking all around the joint pieces of 1½ by 3 inch fir, 12 feet long.

The waling and screening was done from October 11 to 19. For the deep water extra large cottonwood poles, 30 to 35 feet long, were necessary, and their handling in the swift deep water was slow and difficult. Good work was done, however, by placing a heavy pole across the front of the piles at about 4 feet from the bottom; this pole was pushed down to its place with small poles spiked to its ends, and held there by nailing these two smaller poles to the waling place.

The screening was stopped at 90 feet from the end on a dry bar.

Miscellaneous.—The pile driver, using the Vulcan Nasmyth steam hammer and other machinery as described in last year's report, was very satisfactory; on several days over 30 piles were driven, the best record being 38 piles in seven and one-half hours. The bottom was usually sand and silt, but in many places a harder layer was found, where the piles drove very slowly.

The first dike in the series which received much of the main current was No. 4; for this reason the screening was started there. Soundings were taken on a line parallel to the dike and 100 feet below it, before and ten days after the screening was done. It was found that the filling in that time averaged nearly 5 feet, and a deepening of 4 feet was made beyond the end of this dike.

The dikes below were very effective in arresting the current and stopping bank caving, but the fill was not as noticeable as at No. 4.

At No. 7 the main river was near the bank, the dike crossed it and reached very shoal water on other side; as the screening progressed, the current was gradually

forced out and, with the help of some sluicing by the *Josephine*, a good channel was made around the outer end.

On October 14 preparations were commenced for closing the work and laying up the fleet. A barge load of material and the pile driver were taken to Rockhaven October 16. Ways were laid on the grade at lower end of Rockhaven Ice Harbor and the driver pulled out October 21, using the *Josephine's* capstans. The remainder of the barges and material were brought up October 20. The ways were relaid for the barges and all hauled out October 22. Storing the property was finished and all work closed October 23, 1895.

Everything was brought up to Rockhaven except 59 piles and the mattress lumber, which were left at the warehouse near the dikes.

The amount of work done and of material used and cost of various parts of the work are given in the detailed statements herewith.

ROCKHAVEN ICE HARBOR.

Early in July preparations were made to complete the work on lower tract, title to which had been obtained last winter. Lines were marked, grade stakes set, and grading started July 8 with 20 teams and 22 men. This force was gradually increased during July until 52 teams and drivers, using drag scrapers, and 56 laborers were at work. The grading was opened up all along the bank from the end of last year's work to the boat-yard site. Work on the yard was started August 1.

By the latter part of August the excavation of earth along the bank down to the boat yard was nearly completed and the forces largely reduced. At the boat yard the lever part was finished by end of August and good progress made on the grade for ways. During September the grading of the bank slopes was finished except on lower part, where there was much rock, and the grade for boat ways, one on seven to 26 feet above low water, was finished for 250 feet from downstream side.

As the funds for this work were about exhausted, the force was again reduced September 7; all were discharged September 18, and the work closed.

The total excavation for this season was 32,054 cubic yards, of which a part was rock; 1,049 cubic yards of the broken rock were hauled by wagon to the head dike at upper end, which was raised from 15 feet above low water, where it was left last year, to 23 feet, being within 1 foot of the original bank.

Watchman's dwelling.—This building was started in June and was described in last year's report. It was finished August 20 and occupied soon after.

Very respectfully, your obedient servant,

H. C. GOULD, *Assistant Engnieer.*

Capt. H. F. HODGES,
Corps of Engineers, U. S. A.

NEW PLANT AND OUTFIT.

Cost of pile driver (floating).

Labor	$898.30	
Lumber, 15,000 feet, at $17.757	266.80	
Iron, bolts, oakum, hardware, etc	127.03	
Pitch, paint, oils, etc	76.60	
Pipe and fittings, repairs, etc	98.13	
Steam hammer, hose, and sheaves	613.50	
Freight on boiler, hammer, etc	145.18	
		$2,225.54

Cost of land driver.

Labor	$38.99	
Lumber	16.00	
Bolts and iron	34.20	
Machinists' work on angle iron, shears, etc	24.45	
Angle iron, 4 pos., 3 by 3 inches by 20 feet	9.90	
4 set spools and axles	77.44	
		200.98
2 skiffs with oars, etc		100.00
Rope, blocks, tools, etc		725.62
		3,252.14

Repair old barges, etc.

Labor	$686.77
Lumber	125.54
Oakum and rope	31.08
Use of jack screws	4.20
Bolts, iron, and nails	11.99
Leather	1.76
Blacksmith's coal	3.00
Repairs to iron yawl	38.00
Total	902.34

Warehouse and office building.

Labor	$90.50
6,900 feet of lumber, at $13.01	90.31
10½ M cedar shingles, at $3	31.50
Windows, doors, and screens	20.93
Hardware	14.96
Painting	5.00
Total	253.20

Supply track and handling material.

Labor, building and changing tracks	$166.31
Unloading cars	130.05
Labor, handling miscellaneous material	130.67
Lumber for platforms, etc	18.75
Freight on rails	52.17
Total	497.95

Grading, clearing banks, etc.

[For roads, ways, ends of dikes, etc.]

Labor	$1,268.05
Tools	15.40
Total	1,283.45

Superintendence, surveys, office, and miscellaneous.

Labor:	
Superintendence	$1,425.00
Surveys, etc	338.31
Clerk, watchman, etc	996.46
Traveling expenses	133.35
Office furniture	28.45
Use of horse and buggy	151.20
Telegrams, express, oils, etc	23.27
Total	3,096.04

Laying up fleet and property.

Gathering up and loading property	$172.06
Towing by *Josephine*	69.33
Hauling out boats and storing property	288.75
Total	530.14

Mattress building.

[In place ready for weighting.]

Labor	$4,274.09
72,500 feet lumber, at $12.70	914.40
24,800 feet lumber, at $12.95	321.16
5,060 feet lumber, at $19.90	100.69
3,010 feet lumber, at $21	63.21
3,387.77 cords willow brush, at $1.331	4,511.54
2,100 pounds annealed wire, at $3.75	78.75
Nails, rope, tools, and miscellaneous articles	228.41
Repair mat jacks	25.39
581 pounds tallow, at 4 cents	23.24
Freight on miscellaneous articles	28.01
Total	**10,568.69**

Mattress weighing.

Labor	$4,911.19
4,361.99 cubic yards, at $1	4,361.99
Use of flat cars	168.50
Use of towboat 22⅜ days, at $26	559.37
Wheeling plank, repair barrows, etc	111.14
Total	10,112.19
Amount of brush per 100 square feet ..... cords..	1,415
Amount of mattress built ..... square feet..	239,500
Amount of stone per square foot ..... cubic feet..	0.494

Piles and driving.

Piling 26,990 feet, at $0.0371	$1,004.03
Freight and switching on piles	3,145.17
Total cost of piles	4,149.20
2,364 feet piles left on hand, at $0.1537	366.42
Cost of piles used	3,782.78
Labor (sharpening, handling, and driving)	1,976.01
Fuel, 63¾ cords wood, at $2.50	159.37
Miscellaneous supplies	18.28
Time of steamer *Josephine,* pulling moorings, moving driver	277.34
Total cost of piles and driving	6,213.78
Number of piles driven	766
Average penetration ..... feet..	22

Waling and screening dikes.

Labor	$1,970.79
32,800 feet lumber, at $12.95	424.76
8,080 feet lumber, at $11.70	94.54
237.28 cords poles, at $2.50 (on banks)	593.20
36.398 cords poles, at $3.25 (delivered)	118.29
16.875 cords poles, at $3.50 (delivered)	59.06
1,536 feet lumber, at $25	38.40
2,500 feet lumber, at $20	50.00
Bolts, washers, nails, etc	225.68
Freight on materials	40.93
Towing by steamer *Josephine* on poles	277.34
Total	3,892.92
Amount of screening ..... linear feet..	2,550
Amount of poles for 100 linear feet ..... cords..	6.38

Material remaining on hand.

12,260 feet lumber, at $12	$147.12
400 bolts three-fourths by 20 inches, at 10 cents	40.00
100 pounds three-fourths inch washers, at 4 cents	4.00
15 cords poles, at $2	30.00
55 cords poles, at $2.25	78.75
149 cords brush, at $1.85	275.65
2,384 linear feet piles, at 15.37 cents	366.42
300 pounds annealed wire, at 3.6 cents	10.80
3 barrels pitch, at $5	15.00
100 pounds washers, at 4 cents	4.00
25 wheelbarrow trays, at 60 cents	15.00
Total	986.74

Miscellaneous data.

Cost of willow brush, delivered (average), per cord	$1.331
Cost of cottonwood poles, delivered (average), per cord	3.607
Cost of rock, in pile, near work, per cubic yard	1.00
Cost of driving piles (average), each pile	2.69
Cost of driving piles (average), per foot of penetration	.122
Cost of piles and driving, per foot of dike	1.81
Cost of mattress, in place for weighting, per 100 square feet	4.413
Cost of mattress weighting, per 100 square feet	4.222
Cost of waling and screening, per linear foot	.855
Cost of dike, per linear foot:	
Piles and driving	1.810
Mattress material and building	2.206
Mattress weighting	2.111
Waling and screening	.855

Cost for work at shore, T-head, and deep water adds 40 per cent. Total cost, $9.773 per linear foot.

Number of dike.	Length of shore to outside of T-head.	Piling.			Mattress.	Waling and screening.
		Mooring.	Dike.	Total number driven.		
	Feet.	*Number.*	*Number.*	*Number.*	*Sq. ft.*	*Lin. ft.*
1	210	6	52	58	20,900	440
2	270	5	64	69	26,400	490
3	460	8	101	109	33,400	920
4	480	8	112	120	34,900	750
5	560	20	119	139	54,900	800
6	570	20	129	149	38,550	790
7	380	11	96	107	27,750	360
	In heads.					
Miscellaneous	350	15	.....	.....	2,700	.....
Total	3,280	93	673	766	239.500	4,550

REPORT OF MR. H. C. GOULD, ASSISTANT ENGINEER, ON PORTLAND CEMENT TESTS.

UNITED STATES ENGINEER OFFICE,
Sioux City, Iowa, January 14, 1896.

CAPTAIN: I have the honor to submit the following report on tests of the Portland cement used in the mooring posts at Rockhaven Ice Harbor:

The cement was from the works of the Western Portland Cement Company, at Yankton, S. Dak. Twenty-five barrels were purchased in April, 1894, brought up the river by the U. S. snag boat *Jesephine*, and delivered at Rockhaven in good order on May 2, 1894. It was kept in a dry place and used in concrete between May 23 and June 4. Samples were taken from every third barrel, placed in heavy paper sacks numbered from 1 to 8, and kept dry.

The sand was from a hill near the Heart River. It was thoroughly washed in clear water until the water was not discolored, then dried and sifted. The size used was that which passed through a sieve of 20 meshes to 1 inch, and was retained on a sieve having in one way 40 meshes and in the other 48 meshes to 1 inch.

Missouri River water was used, after being thoroughly cleared by settlement.

In making the tests the programme recommended by the American Society of Civil Engineers was followed as far as practicable.

There were made from each of the 8 samples 2 pats neat cement (water, 25 per cent), 8 briquettes neat cement (water, 25 per cent), and 8 briquettes of one part cement to two parts sand (water, 13 per cent). Those from samples 1 to 4 were made from July 19 to 28; from samples 5 to 8 between October 9 and 20. The pats were observed for color, time of setting, and for checking.

The briquettes were kept under water, in galvanized iron boxes, 14 by 16 by 2 inches, each box holding the 16 briquettes of one sample, with each briquette numbered to correspond with its notebook number. The boxes were packed in a case filled with water and shipped to Sioux City about November 10, 1894.

The gauging was done in a shallow oval granite-iron pan, with a small mason's trowel. Mortar for two briquettes of neat cement or for four of part cement and sand were mixed at one time.

The molds were the single type, with separable halves held together by a screw clamp. They were filled with four to six layers, firmly pressed in with a small trowel.

The temperatures could not be kept uniform, as the circumstances did not justify the expense of special arrangements for this purpose. At each mixture the temperatures of the air, cement, and sand were usually the same, while that of the water was 5° to 10° lower. The variations were approximately as follows:

	°	°
Sample No. 1	70 to	90
Sample No. 2	70 to	98
Sample No. 3	69 to	102
Sample No. 4	67 to	100
Sample No. 5	66 to	72
Sample No. 6	64 to	73
Sample No. 7	64 to	74
Sample No. 8	60 to	74

The briquettes were broken at the city engineer's office in one of the small-sized testing machines, in which the strain is applied by a stream of small shot at the rate of approximately 800 pounds per minute.

RESULTS.

The color of all the pats left in the air was a light bluish gray.

The average time of setting was 5 hours 7 minutes.

No checking occurred in any of the pats left in air.

Of those placed in water, Nos. 1 to 3 checked badly and scaled up on the surface in from one to two hours after immersion; Nos. 4, 6, and 8 showed no checks whatever, while Nos. 5 and 7 showed only a very small check near the edge.

The tensile strength is shown in the following table:

Number of sample.	Neat cement.					
	Six weeks.		Six months.		One year.	
	Number tested.	Average strength.	Number tested.	Average strength.	Number tested.	Average strength.
1	.....	.....	7	594	7	629
2	.....	.....	7	670	6	583
3	.....	.....	7	644	7	584
4	.....	.....	8	566	8	692
5	.....	.....	.....	.....	13	658
6	12	374	.....	.....	4	597
7	14	406	.....	.....	.....	.....
8	8	328	.....	.....	7	531
Total	34	376	29	614	52	605

[Cement, 1 part; sand, 2 parts.]

Number of sample.	Five weeks.		Six months.		One year.	
	Number tested.	Average strength.	Number tested.	Average strength.	Number tested.	Average strength.
1	.....	.....	8	387	8	405
2	.....	.....	8	426	7	403
3	.....	.....	8	382	8	388
4	.....	.....	8	378	8	380
5	.....	.....	.....	.....	15	326
6	16	249	.....	.....	.....	.....
7	2	216	.....	.....	6	304
8	8	289	.....	.....	8	358
Total	26	258	32	292	60	364

Very respectfully, your obedient servant,

H. C. GOULD, *Assistant Engineer.*

Capt. H. F. HODGES,
Corps of Engineers, U. S. A.

REPORT OF MR. W. G. PRICE, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Sioux City, Iowa, November 1, 1895.

CAPTAIN: I have the honor to submit the following report of the work at Pierre, S. Dak., to date:

At the time of the annual report, on July 1, 1895, work was in progress on the plant and on Dam No. 3.

A description of the plan of construction of Dam No. 3 and of the dikes at Fort Pierre and Pierre was given in that report.

The plant was completed on July 30. Work on Dam No. 3 was continued, but was much delayed by high water in July. A portion of the dam near the center of the chute, but not in the deepest water, began to settle. The head of water produced by closing the chute caused the water to make its way under the foundation mattress and to wash out the sand.

Some settlement was also probably due to the material composing the bed of the chute being too soft to support the crib of the dam when heavily loaded with rock. As the dam settled down the cribs were built up again, and a thick filling of buffalo berry brush was placed on the upstream side and heavily weighted with rock to stop the water from washing under the dam. After the water had fallen too low to wash the sand from under the dam, it continued to settle, and on August 6 work on it was suspended.

On September 12 the settlement of the dam having stopped, work was again resumed, and it was built up to grade and heavily ballasted with rock.

There has been no settlement since the completion of it. As soon as the mattress had been completed across the chute the sand began to fill in rapidly for some distance above and below the dam, and continued to do so as long as there was sufficient current to move the sand.

Work on the dikes at Fort Pierre was begun on July 12, and the five dikes were completed on September 24. The Vulcan steam hammer did very efficient work in driving piles, but the progress was very slow, owing to the very hard material into which they had to be driven. This material consisted of about 10 feet of sand, underlaid with about 8 feet of glacial bowlders, and under the bowlders the piles penetrated into very hard material supposed to be shale. Some of the piles struck the bowlders and could not be driven farther, while others were thrown much out of plumb while being driven through the stratum of bowlders. The average penetration of the piles driven in the dikes at Fort Pierre was 24.87 feet. An attempt was made to pull up the mooring piles, using the snag boat *Mandan*, and afterwards the snag boat *James B. McPherson*. A few of them which penetrated only into the sand were pulled up, but those which penetrated into the bowlders or shale could not be pulled up. Those which were outside the line of the dikes were broken off at a depth of 10 feet below low water. Those inside the line of the dikes were left standing. Piles were not driven on the bars where the pile driver hull could not be floated, but in place of the piles a crib was built of cottonwood poles filled with rock, on the same plan as was used for Dam No. 3. These cribs extended from the high banks to the water's edge, where they were fastened to the piling. The top of the waling pieces at the T-head was 5 feet above low water and extended toward the top of the high bank with a curved rise. The top of the cribs began even with the top of the waling pieces and continued the curved rise to the top of the bank, which is 15 feet above low water. The cribs were fastened to the mattress with wire strand and the upstream angle formed by the crib and mattress was filled with rock. The stem of the dikes was screened with cottonwood poles placed 3 inches apart in the clear and nailed to the downstream waling piece. The T-heads were completely screened by poles which were nailed 4 inches apart in the clear to all waling pieces. A fill has taken place below all of the dikes, amounting to 10 feet in one case and extending out nearly even with the end of the T-head piles.

Work was begun on the dikes at Pierre on September 9, and two dikes were completed on October 10.

These dikes are located 800 feet and 1,510 feet below the steamboat landing. The upper dike is 285 feet long to end of mattress and the lower dike is 540 feet long.

Owing to a sand bar which had formed along the shore, no piles could be driven in the lower dike with a floating driver, and in the upper dike the T-head and 12 piles in the stem of the dike only were driven, and these were connected with the bank by a crib the same as in the dikes at Fort Pierre. The average penetration of the piles in the upper dikes was 28.19 feet. The material was very hard and is supposed to be shale. Only two of the piles in this dike were stopped by striking glacial bowlders. In the lower dike a crib was built which extended out 345 feet from the bank to a high part of the sand bar, where it was tapered down to the level of the

mattress. All the mattress on the bars was covered with a heavy continuous layer of rock to prevent the destruction of the mattress by floating ice.

On September 28 preparations were begun to haul out the barges and pile driver, using the ways on which they were launched, situated just above the upper dike at Pierre. This work was finished on October 10, and then a small house for the watchman was built and finished on the 14th. All property was put in good condition for care by the watchman and was turned over to him on October 14.

The distribution of expenses of the work at Pierre is shown in the inclosures which accompany this report.

Very respectfully, your obedient servant,

W. G. PRICE,
Assistant Engineer.

Capt. H. F. HODGES,
Corps of Engineers, U. S. A.

Cost of 1 pile driver and 4 barges.

Labor	$3,969.63
Lumber	2,186.30
Steam pile hammer, with hose, etc	613.00
Iron	72.16
Bolts, nails, etc	136.80
Gas pipe, fittings, etc	86.02
Two capstans and bars	70.00
Fire brick, etc	11.92
Grate bars, etc	16.49
Rope, oakum, oil, etc	219.75
Deck pump and hose, etc	46.64
Blocks, etc	6.87
Traveling expenses	28.45
Total	7,464.03

Care of plant.

Watchman (night) and building watchman's house	$163.20
Lumber used for building watchman's house	22.62
Stove, etc	10.10
Hauling out plant	172.56
Total	368.48

Cost of plant aside from pile dviver and barges.

Blocks, anchors, etc	$114.58
Mat jacks, etc	48.00
Tools, etc	24.62
Rope, etc	120.70
72 wheelbarrows	120.00
8 lanterns and wicks	6.25
3 oil cans	7.00
1 grindstone and fixtures	9.65
2 pieces steam hose	90.00
Water casks	.95
Total	541.75

Cost of water gauges set up at Fort Pierre.

Gauge	$110.00
Padlock	.50
Logs	4.50
Labor	16.61
32 pounds barbed wire, at 5 cents	1.60
Total	133.21

Cost of Dam No. 3.

Labor	$2,928.53
527 cords willow brush, at 95 cents	500.65
262.7 cords poles, at $2.30	604.21
30 cords poles, at $1.50	45.00
Transportation of brush and poles	697.85
1,100.63 cubic yards broken stone, at $1.73	1,904.19
20,327 feet B. M. mattress lumber, at $20.90 per thousand	424.83
50 pounds wire, No. 12, at 3 cents	1.50
560 pounds wire spikes, 6-inch, at 3 cents	16.80
100 pounds wire spikes, 6-inch, at 4 cents	4.00
150 pounds wire spikes, 9-inch, at 2 cents	3.00
525 pounds wire nails, 30d., at 2 cents	10.50
2,800 pounds wire strand, at 3 cents	84.00
800 pounds wire spikes, 9-inch, at 3.8 cents	30.40
65 pounds fence staples, at 5 cents	3.25
Entire cost of dam	7,258.71

Total length of dam, 925 feet.

Cost of dikes at Fort Pierre.

313 feet mooring piles, at 27 cents	$84.51
8,100 feet white-oak piling, at 27 cents	2,187.00
Driving mooring piles	47.68
Driving 208 piles, average penetration 24.87 feet	414.72
11,370 feet B. M. waling pieces, at $20.90 per thousand	237.63
506 bolts, 20 and 22 inch, at 7 cents	35.42
10 bolts, 17 inch, at 11 cents	1.10
100 cords willow brush, at 95 cents	95.00
1,649 cords willow brush, at 73 cents	1,203.77
170 cords cottonwood poles, at $1.50	255.00
Transportation of brush	896.16
Transportation of poles	143.90
Building 108,250 square feet mattress	1,434.37
38,749 feet B. M. mattress lumber, at $20.90 per thousand	809.85
5,251 feet B. M. mattress lumber, at $22.15 per thousand	116.31
1,284 cubic yards broken stone, at $1.73	2,186.72
Building cribs, ballasting mattress, etc	1,517.96
Transportation of piling	153.59
1,030 pounds wire strand, at 3 cents	30.90
1,675 pounds wire nails and spikes, at 2 cents	33.50
700 pounds wire nails and spikes, at 4 cents	28.00
300 pounds wire nails and spikes, at $4.40 per cwt	13.20
20 tons coal, at $4.14	82.80
30 pounds fence staples, at 5 cents	1.50
Oil used on pile driver	7.90
Entire cost of dikes at Fort Pierre	12,018.49

Cost of dikes at Pierre.

896 feet white-oak piling, at 27 cents	$241.92
Driving 26 piles, an average penetration of 28.19 feet	56.13
1,512 feet B. M. waling pieces, at $20.90 per thousand	31.60
66 bolts, 20 and 22 inch, at 7 cents	4.62
260.56 cords willow brush, at 73 cents	190.21
434.58 cords willow brush, at $1.25	543.22
6,092 feet B. M. mattress lumber, at $22.15 per thousand	134.94
8,303 feet B. M. mattress lumber, at $23	190.97
Transportation of brush	166.31
Transportation of poles	68.50
55. 6 cords cottonwood poles, at $1.50	83.40
Building 49,610 square feet mattress	675.34
Building cribs, ballasting mattress, etc	675.13
1,056.79 cubic yards broken stone, at $1.07	1,130.77
1,730 pounds wire strand, at 3 cents	51.90
200 pounds wire nails and spikes, at $4.40 per cwt	8.80
1,081 pounds wire nails and spikes, at 4 cents	43.24
2½ tons coal, at $4.14	10.35
15 pounds fence staples, at 5 cents	.75
Total cost of dikes at Pierre	4,308.10

Cost of material on hand at Pierre.

141 piles, total length 5,159 feet, at 27 cents	$1,392.93
68 pounds nails, at $4 per cwt	2.72
50 pounds nails, at $4.40 per cwt	2.20
90 pounds wire strand, at 3 cents	2.70
40 pounds galvanized wire, at 3 cents	1.20
2,156 feet B. M. lumber, at $30 per thousand	64.68
6,720 feet B. M. running plank, at $20.90 per thousand	140.45
660 feet B. M. mattress lumber, at $22.15 per thousand	14.62
4,542 feet B. M. waling pieces at $20.90 per thousand	94.93
178 bolts, at 7 cents	12.46
190 bolts, at 11 cents	20.90
143 pounds iron, at 2 cents	2.86
90 pounds oakum, at 6 cents	5.40
155 pounds iron (mat pins), at 2 cents	3.10
7 barrels pitch, at $5	35.00
1 barrel rosin oil	15.00
Stove, etc	10.95
Total	1,822.10

Improvement of the Missouri River at Pierre, S. Dak.

Cost of mattress in Dam No. 3 per 100 square feet	$4.45
Cost of mattress in position for sinking in dikes per 100 square feet	$4.155
Cost of willow brush per cord, delivered at work	$1.367
Cost of cottonwood poles per cord, delivered at work	$2.89
Cost of rock on left bank per cubic yard	$1.07
Cost of rock on right bank per cubic yard	$1.73
Cost of driving piles per foot penetration	$0.097
Number of piles driven in dikes	234
Total cost of driving same	$571.90
Total cost of dikes at Fort Pierre	$12,018.49
Total cost of dikes at Pierre	$4,308.10
Total length of Dam No. 3 feet	925
Cost per linear foot of same	$7.847
Total length of dikes at Fort Pierre feet	1,725
Cost per linear foot	$6.976
Total length of dikes at Pierre feet	845
Cost per linear foot	$5.089
Number of cords of willows used in a mattress 50 by 50 feet at Dam No. 3	30
Number of cords of willows used in a mattress 50 by 50 feet in dikes	38.7
Cost of plant (barges and pile driver)	$7,464.03
Care of plant	$368.48

REPORT OF MR. F. M. TOWAR, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Sioux City, Iowa, January 7, 1896.

CAPTAIN: I have the honor to submit the following report of the operations under my supervision since June 30, 1895, together with an account of some preparatory work done during the preceding May and June.

The work was confined to the improvement of the bank and channel of the Missouri River, on the part of Sioux City, on the Iowa shore from Brughier Bridge, near the upper limits of the city, extending down the river about a mile.

Your project, approved April 13, 1895, provided for the construction of 20 pile dikes covering this reach of the river, located from 200 to 300 feet apart, extending out into the river from 100 to 250 feet. This project was afterwards modified, reducing the number of dikes to 16, with a distance between them of from 300 to 500 feet, extending into the river a distance of from 200 to 400 feet. (See accompanying map.)

During May and June of 1895 the old plant had been repaired, consisting of the construction of a mattress barge from two old barges bolted together end to end, making a boat about 100 feet long, the repair of the small steamer *Josie* to be used

as a towboat, and the commencement of the construction of a new mattress barge, 100 by 20 feet by 4.5 feet, to be used in conjunction with the old one for weaving mattresses from.

A small force of men was put to work July 1 to grade the bank, unload rock, etc.

July 9, weaving and ballasting the mattresses at Dike 1 with the crew of one mattress barge and a ballasting crew of 15 men was commenced; the work progressed slowly with this small crew until July 26, when the new barge was ready for use.

Dike 5 was the first one on which both barges were used together, as follows: Both barges, each about 100 feet long, were placed end to end and moored in the river, their length being placed about normal to the current in the direction proposed for the projected dike; they were held in place by 1¼-inch manila rope fastened to mooring piles 150 feet up the river. After the barges were thus gotten in position a width of about 20 feet of mattress was woven over the entire length of the two barges, then the barges were pulled from under and another 20 feet woven, and 20 feet on until the mattress was complete and afloat. In most cases a whole dike was woven in one piece, as few of them were more than 225 feet in length.

The mattress was held rigidly in place by wire cables fastened to the mooring piles above and lashed to the cables of the selvage in the upper edge.

In construction the usual methods were employed. (See description of Dike 10, Chief of Engineer's Report, 1895, p. 2231.)

From July 9 to 26, inclusive, one-third of Dike 1 and the whole of Dikes 3 and 4 were woven with one mattress barge. On July 27 work was commenced with both mattress barges and a full crew of weavers, etc.; from the latter date to October 3 Dikes 5 to 16, inclusive, two-thirds of Dike 1, and the whole of Dike 2 were woven. The sinking and ballasting followed the weaving within a few days.

Pile driving in the dikes commenced on August 14, and was finished on November 4; during this time 761 piles were driven to an average penetration of 19.58 feet.

The mooring piles were driven for several of the first dikes before any work was commenced, but afterwards it was found better to drive these piles as the work progressed.

Bracing and screening commenced October 9; the bracing was completed November 16 and the screening November 25.

On November 17, on account of the threatened closing of the Missouri River, the barges, towboat, and other plant were taken to the Big Sioux River and placed in winter quarters.

The mattress-building crew was made up as follows: One mat boss or head weaver, 12 weavers, 12 brush passers, 7 brush carriers, and about 4 other men for miscellaneous work, moving barges, toggling, placing wire cables, and other necessary work.

The ballasting crew consisted of 2 foremen and 24 men, 1 foreman and 16 men to load the barges from the rock pile on the bank, the other with 8 men to sink and ballast the mattress from the loaded barges; this crew also unloaded the rock from cars.

The bracing and screening crew was composed of a foreman and 10 men; they worked from barges, one on either side of the dike; the barges were fitted with capstans, used to pull the piles into line before bracing.

Two accidents occurred during the season, which resulted in some loss of time and considerable material and a few tools. The first one occurred on August 23. As we were sinking the mattress of Dike 8, two of the mooring piles gave way, letting it drift down about 30 feet before it could be sunk to the river bottom; the piles were consequently driven irregularly in this dike to conform to the changed position of the mattress. (See accompanying map.)

Although precautions were taken in sinking the mattress of Dike 9, mooring piles again gave way; this time the cables holding the mattress broke, the mattress drifted around with the current and broke in two at the inner end of the T-head, moved rapidly down against the partly completed mattress of Dike 10, carrying it away and quite seriously disabling both mattress boats.

After these accidents it was deemed necessary to drive a greater number of piles; the number adopted as necessary and afterwards found to be sufficient was, in from 15 to 22 feet of water clusters of three, in from 10 to 15 feet two, in less than 10 feet only one in a place was found sufficient.

All the work was done by hired labor, except pile driving and furnishing willow brush. The pile driving cost 8.4 cents per linear foot of pile, the brush cost delivered on barges at the dike $1.60 per cord.

Appended are statements giving the cost of various classes of the work compiled from an accurate record of the amount of labor employed, and of the material used, also a table showing in detail the work accomplished.

Very respectfully, your obedient servant,

F. M. TOWAR,
Assistant Engineer.

Capt. H. F. HODGES,
Corps of Engineers, U. S. A.

Plant.

New barge, 100 by 20 feet by 4.5 feet:		
Labor		$623.18
Lumber		158.18
Bolts, washers, etc		13.87
Ship spikes		10.93
Nails		6.60
Paint		7.50
Freight on lumber		243.78
Oakum		16.50
		$1,080.54
Repair of steam launch *Josie:*		
Labor	67.00	
Lumber	4.80	
		71.80
Repair of old barges:		
Labor	360.03	
Lumber	69.31	
Oakum	10.50	
Paint and nails	11.80	
		451.64
Total		1,603.98

Mattress building.

Driving mooring piles, hire of pile driver, labor, etc	$535.58	
Coal	37.47	
Labor, weaving, etc	4,052.40	
Brush delivered at dike	4,238.96	
Wire cable	872.42	
Manila rope	116.19	
Cord wood (for toggling)	23.75	
		$9,874.77

Mattress weighting.

Labor	2,945.76	
Rock	1,528.63	
Switching	577.50	
Towing	845.00	
Coal	160.00	
Oil	5.60	
Freight on rock	6,045.67	
Unloading rock	264.74	
		12,372.92

Grading.

Labor	182.72
Total	22,430.41

Piling.

Oak piles	$1,653.25
Pine piles	393.88
Freight on oak piles	2,119.81
Freight on pine piles	296.77
Driving piles (for dike)	2,448.51
Unloading piles	107.92
Switching piles	150.00
Total	7,170.14

Bracing and screening.

Towing poles	$60.00
Labor	927.69
Lumber	252.95
Poles	224.28
Bolts and washers	134.74
Spikes	28.90
Nails	22.55
Freight on lumber	487.36
Coal	15.00
Total	2,153.47

Miscellaneous.

Repairs, machinist, blacksmith, etc	$66.16
Tools	167.90
Miscellaneous labor	112.76
Hire of barges	118.00
Surveys (labor)	45.00
Total	509.82

Engineering, etc., and care of plant.

Pay of assistant engineer, overseer, inspector, and watchman $2,562.83

Table showing work accomplished.

Dike.	Length.	Piles.		Total piles.	Mattress.	Bracing and screening.	Piles, average penetration.	Piling driven.
		Dike.	Mooring.					
	Feet.				*Sq. feet.*	*Lin. feet.*	*Feet.*	*Feet.*
1	235	76	3	79	27,350	225	16.98	2,239
2	398	76	3	79	25,000	388	19.19	2,399
3	268	52	2	54	18,500	258	20.25	1,732
4	225	42	2	44	16,350	215	20.47	1,461
5	198	36	2	38	15,000	188	19.44	1,299
6	210	40	4	44	15,600	200	18.95	1,534
7	219	58	8	66	17,340	209	19.03	2,401
8	235	49	8	57	16,850	225	20.04	2,142
9	220	44	11	55	16,100	210	18.55	1,766
10	215	40	11	51	15,850	205	19.86	1,758
11	215	38	10	48	15,850	205	21.09	1,629
12	199	38	9	47	15,050	188	21.03	1,592
13	185	34	8	42	14,350	175	19.53	1,447
14	195	34	8	42	14,850	185	20.04	1,496
15	225	44	8	52	16,350	215	19.42	1,803
16	305	60	6	66	21,850	295	19.39	2,451
Total	3,747	761	103	864	282,240	3,587	19.58	29,149

Unit cost of material, labor, etc.

Willow brush, per cord, delivered	$1.60
Willow poles, per cord, delivered	2.77
Rock, per cubic yard, delivered	1.13
Rock, per cubic yard, unloaded	1.161
Driving piles, each average	3.45
Driving piles, per foot penetration	.165
Driving piles, per foot for total length of pile	.084
Driving piles and cost of same per linear foot of dike	1.91
Cost of piles, per linear foot, including freight, unloading, switching, etc	.168
Mattress afloat in place, per 100 square feet	3.20
Mattress sinking and weighting, per 100 square feet	4.01
Cost of piles, driving, unloading, etc., per 100 square feet	2.32
Total cost of dike per 100 square feet of mattress	10.23
Total cost of dike per linear foot	9.12

COMMERCIAL STATISTICS.

River tonnage between Sioux City, Iowa, and Stubbs Ferry, Montana (exclusive of live stock).

Year.	Tons.	Year.	Tons.
1887	13,961	1892	15,182
1888	12,895	1893	13,837
1889	16,724	1894	25,151
1890	13,326	1895	21,262
1891	13,055		

Traffic by river reaches.

Year.	River reaches between—	Packages and bulk freight.	Passengers.	Live stock.
		Tons.		*Head.*
1890.....	Sioux City and Bismarck.....	9,735	4,322	2,974
	Bismarck and Fort Buford.....	2,467	184	43
	Fort Buford and Fort Benton.....	1,124	62	43
1891.....	Sioux City and Bismarck.....	10,410	1,749	4,683
	Bismarck and Fort Buford.....	2,645	130	59
1892.....	Sioux City and Pierre.....	2,634	32	6,043
	Pierre and Bismarck.....	7,247	177	2,315
	Bismarck and Fort Buford.....	5,301	278	300
1893.....	Sioux City and Pierre.....	5,456	12,513	23,137
	Pierre and Bismarck.....	6,256	137	20
	Bismarck and Fort Buford.....	2,125	12	2
1894.....	Sioux City and Pierre.....	1,491	3,095	9,258
	Pierre and Bismarck.....	19,171	16,362	41,356
	Bismarck and Fort Buford.....	4,461	102	1,849
	Great Falls and Stubbs Ferry.....	28	903	.....
1895.....	Sioux City and Pierre.....	10,485	.....	.....
	Pierre and Bismarck.....	5,136	417	7
	Bismarck and Fort Buford.....	5,591	8	.....
	Great Falls and Stubbs Ferry.....	50	2,204	.....

Abstract of proposals for furnishing 14 mooring posts, 14 caps, and 56 cap screws for Sioux Ice Harbor, opened by Lieut. Col. W. A. Jones, Corps of Engineers, at Sioux City, Iowa, at 2 p. m., April 30, 1896, in accordance with circular letter dated March 31, 1896.

No.	Bidder.	Location.	Price per—			Point of delivery.	Total cost f. o. b. cars.	Remarks.
			Post.	Cap.	Cap screw.			
1	Vulcan Iron Works.	Chicago, Ill....	$48.52	$1.09	$0.045	Chicago...	$697.06	Can not agree to deliver on time specified.
2	American Hoist and Derrick Co.	St. Paul, Minn.	51.49	1.50	0.03	.....do	743.54	Informal. Specifications and print not attached.
3	The Gillette-Herzog Manufacturing Co.	Minneapolis, Minn.	42.00	3.45	0.24	Pittsburg.	649.74	Informal. Blue print not attached.
4	Jos. F. Wangler Boiler and Sheet Iron Works Co.	St. Louis, Mo ..	47.00	4.00	0.10	St. Louis..	719.60	Do.
5	Richard Garstang ..	.....do	52.50	1.81	0.05	.....do	763.14	Informal. Specifications and print not attached.
*6	James Rees & Sons Co.	Pittsburg, Pa..	42.50	2.50	0.06	Pittsburg.	633.36	Informal. Blue print not attached.

*Contract awarded James Rees & Sons Co.

List of steamers plying on the Missouri River between Sioux City, Iowa, and Stubbs Ferry, Montana, during the year 1895.

Name.	When built.	Dimensions.			Tonnage	Manager or owner.
		Length.	Breadth.	Depth.		
		Feet.	*Feet.*	*Feet.*		
Mary E. Bennett...	1888	65	14	2	21.71	R. A. Talbot, Sioux City, Iowa.
Capitola Butt.....	1885	83.7	23.3	3.3	57.31	Do.
Vint Stillings.....	1881	131	31.8	4.8	177.47	Selzer Bros., Sioux City, Iowa.
Josie L. K	1884	60	14	2.5	22.75	A. Larson, Yankton, S. Dak.
Little Maud	1882	92	20	3.4	58.66	Jos. Leach, Running Water, S. Dak.
Last Chance	1870	98.2	17.8	3	50.47	H. J. King, Chamberlain, S. Dak.
Jim Leighton.....	1893	119.5	30.16	3.6	57.29	B. F. Horn, Pierre, S. Dak.
Castalia	1892	110	24	3.6	75	B. S. Holmes, Sioux City, Iowa.
Batchelor.....	1878	178.6	31	4	313	I. P. Baker, Bismarck, N. Dak.
Rosebud	1877	177.4	31.3	4	286.49	Do.
Imelda	1892	90	17	2	30	D. B. Weatherbee, Fort Yates, N. Dak.
Rose.....	1886	44	10	2.75	Less than 50 tons.	N. Hilger, Helena, Mont.
J. J. Hill.	1892	50	10	4½		J. D. Taylor, Great Falls, Mont.
Minnie	1892	50	10	4½		J. W. Cornelius, Great Falls, Mont.
Francis.....	1892	29	7	3		J. Klenetco, Great Falls, Mont.

IMPROVING UPPER MISSOURI RIVER IN FRONT OF SIOUX CITY, IA.

PILE DIKES NOS. 1 TO 16 INCLUSIVE.

Built under the direction of

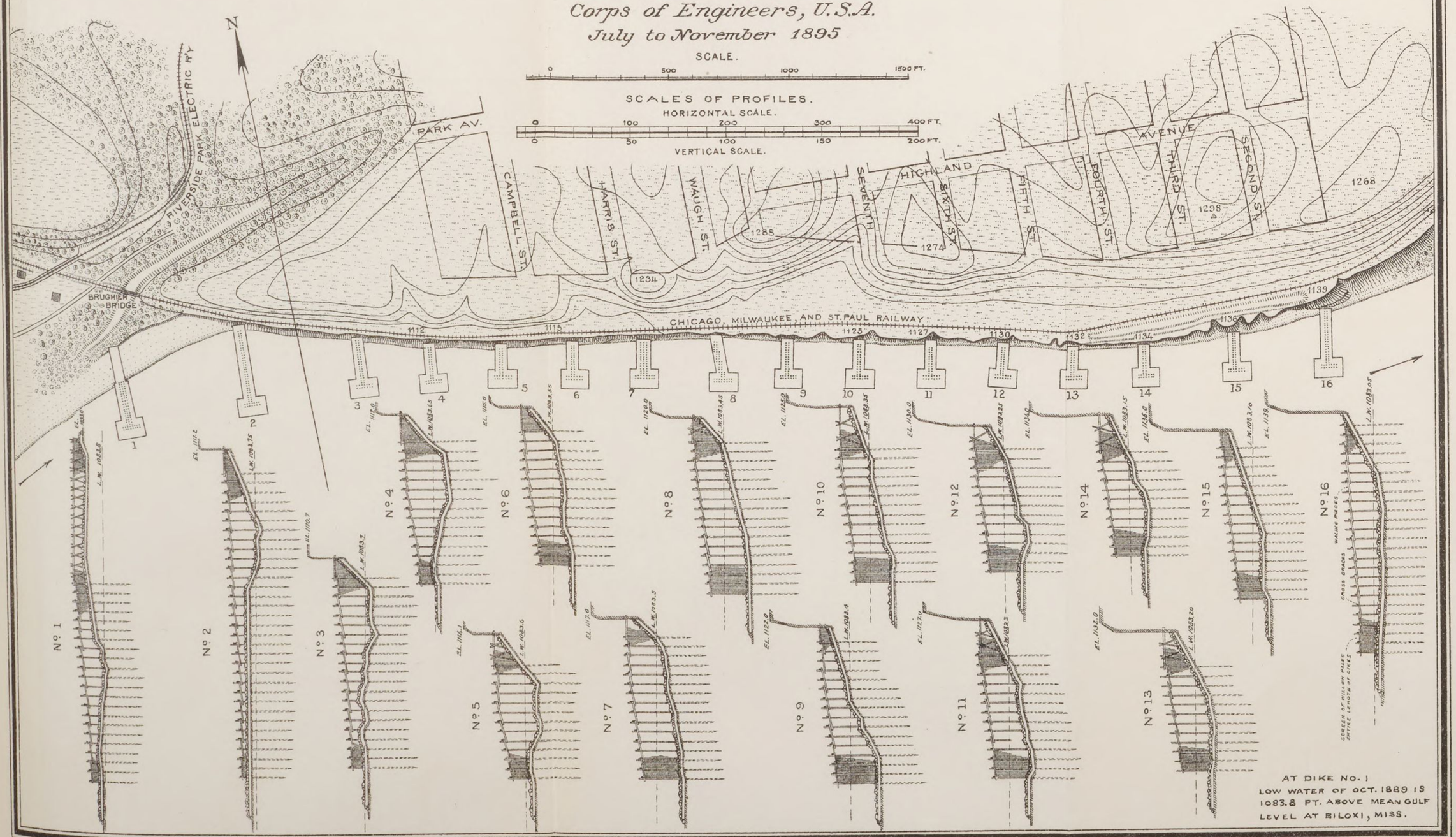
CAPTAIN H.F. HODGES

Corps of Engineers, U.S.A.

July to November 1895

Note.
Elevations in feet are referred to mean Gulf level at Biloxi, Mississippi.

Contours 20 ft. apart vertically



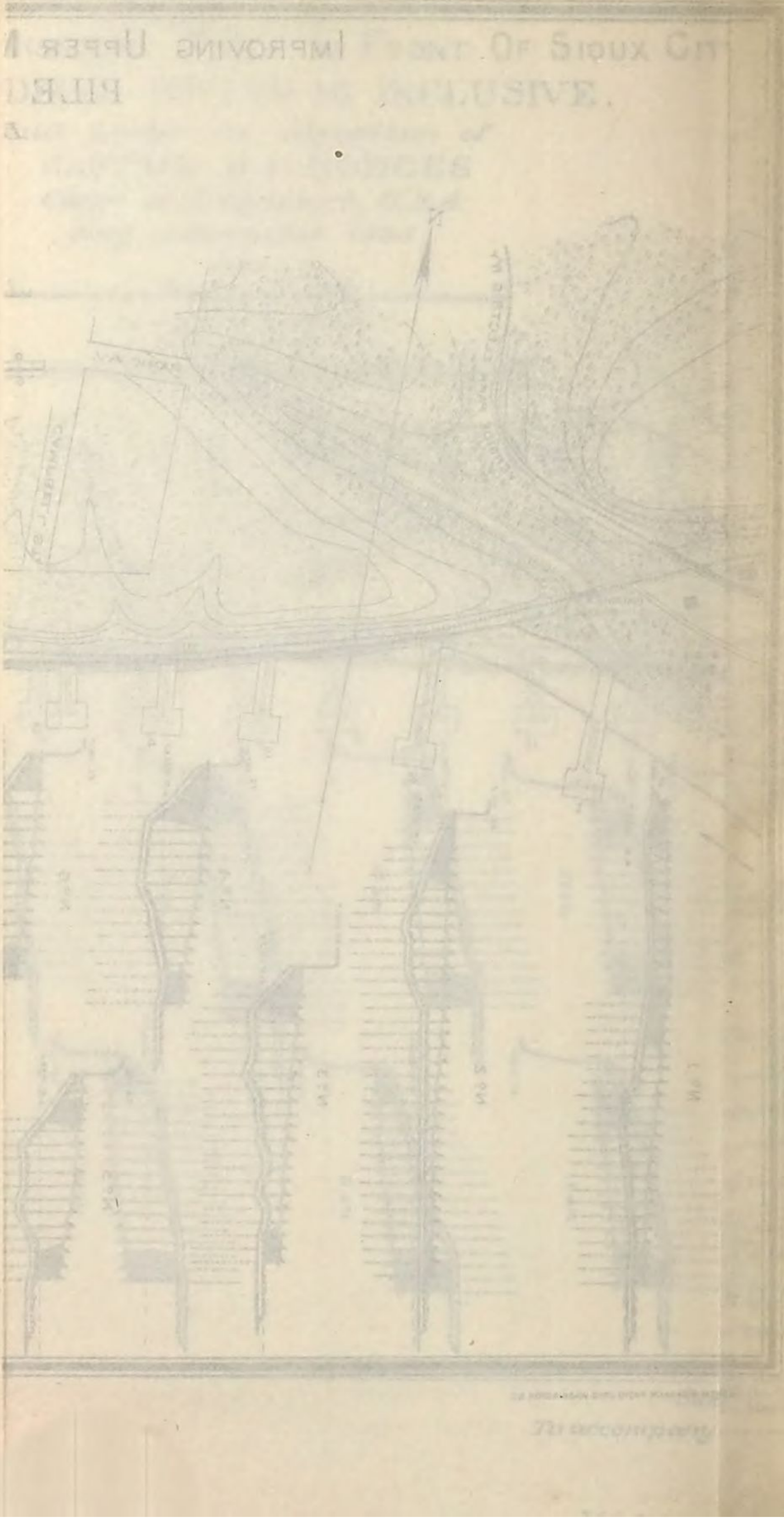
ANDREW B. GRAHAM, PHOTO-LITHO, WASHINGTON, D.C.

Sioux City, Ia. July 15th 1896 Eng 54 2

To accompany Annual Report of this date

W. A. Jones

Lieutenant Colonel, Corps of Engineers, U.S.A.



IMPROVING UPPER MISSOURI RIVER

AT PIERRE S. DAK.

PILE DIKES

Built under the direction of

CAPTAIN H.F.HODGES

Corps of Engineers U.S.A.

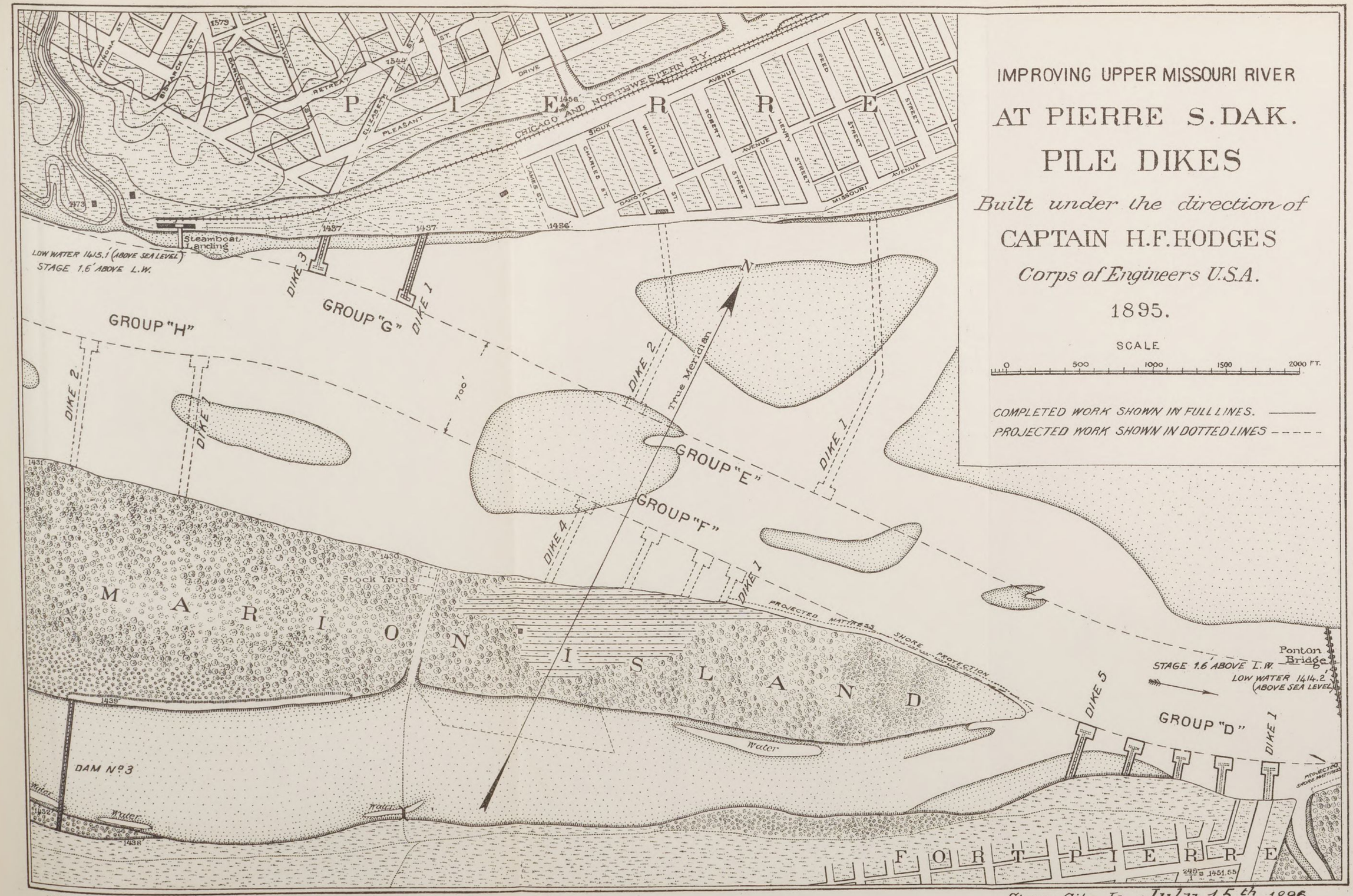
1895.

SCALE

0 500 1000 1500 2000 FT.

COMPLETED WORK SHOWN IN FULL LINES. ———

PROJECTED WORK SHOWN IN DOTTED LINES - - - - -



ANDREW B. GRAHAM, PHOTO-LITHO. WASHINGTON, D.C.

Eng 54 2

Sioux City, Ia. July 15th 1896

To accompany annual report of this date

Lieutenant Colonel, Corps of Engineers U.S.A.

Eng 54 2

IMPROVING UPPER MISSOURI RIVER.

PLAN SHOWING

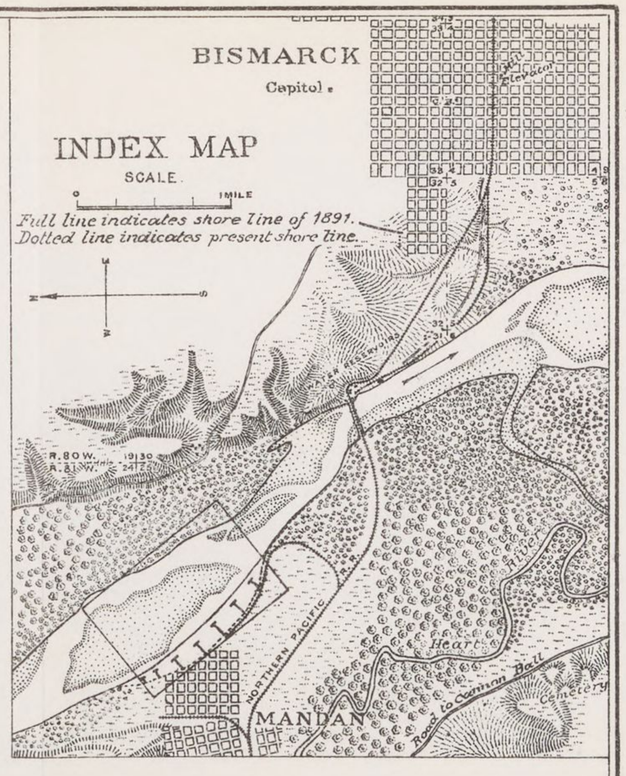
DIKES BUILT AT MANDAN N.D.

DURING THE YEAR ENDING

JUNE 30TH. 1896

SCALE.

0 500 1000 1500 FT.



ANDREW B. GRAHAM, PHOTO-LITHO. WASHINGTON, D.C.

Eng 54 2

Sioux City, Ia. July 15th 1896

To accompany Annual Report of this date

M. M. Jones

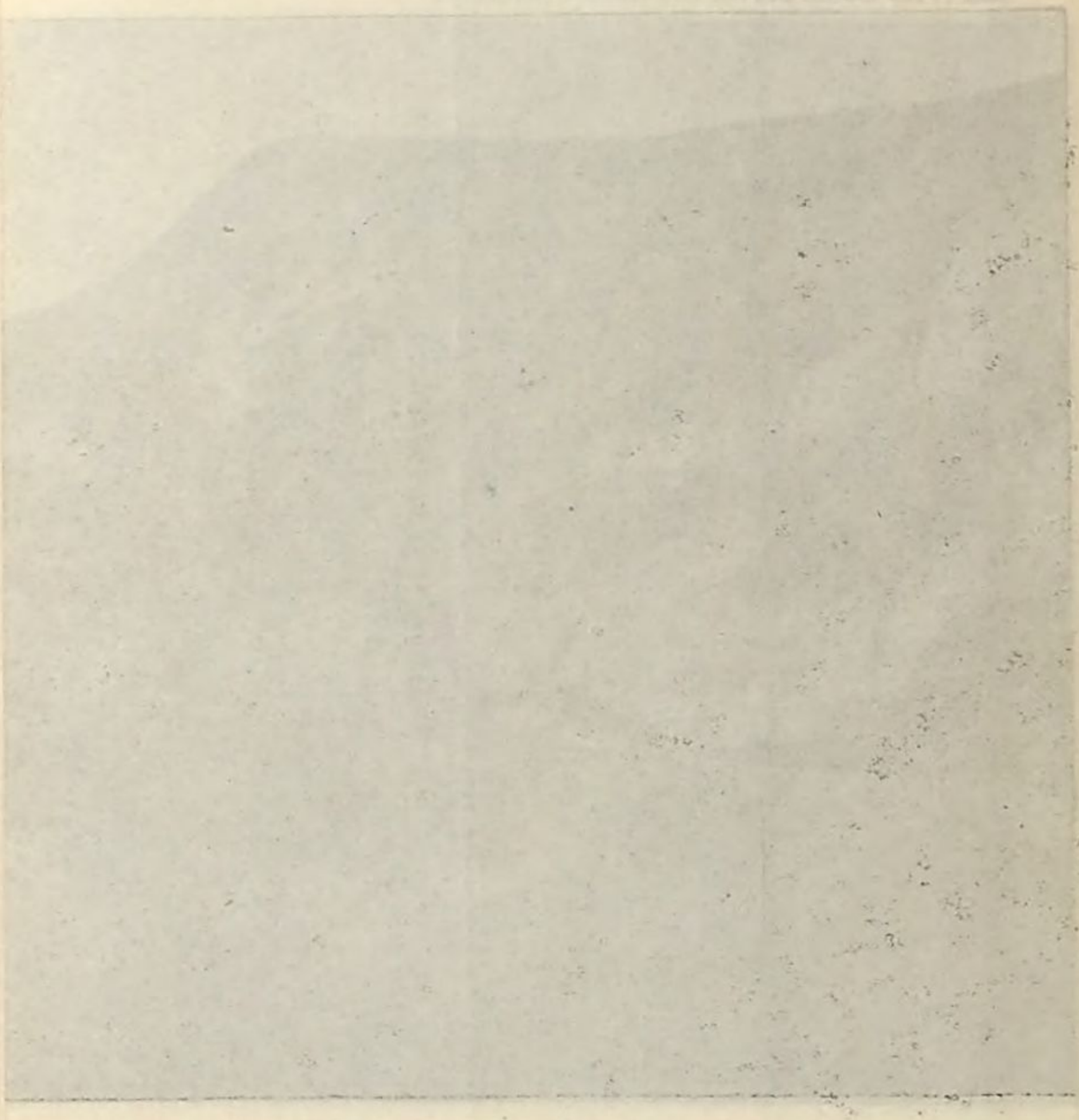
Lieutenant Colonel, Corps of Engineers U.S.A.

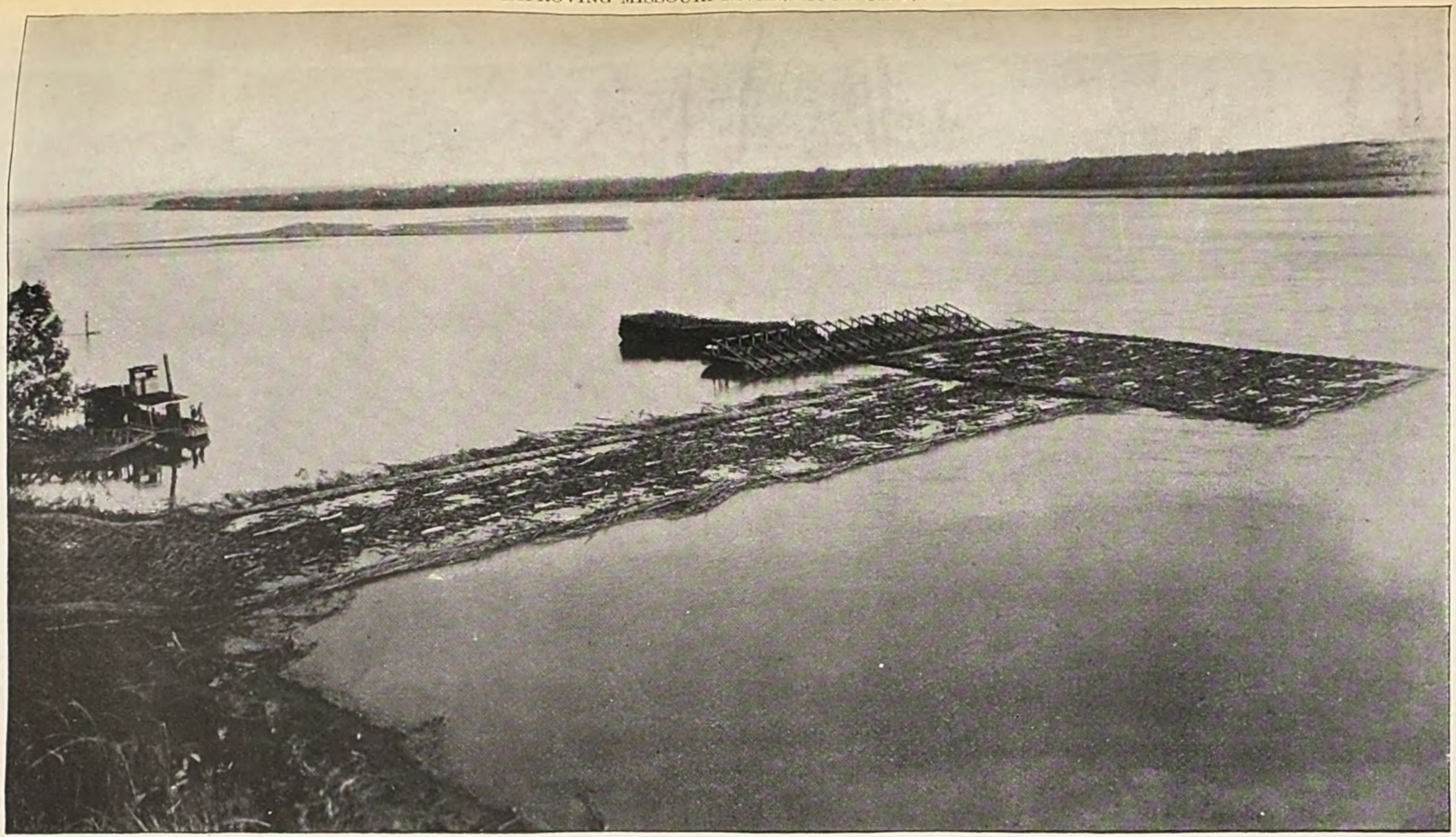


IMPROVING MISSOURI RIVER, SIOUX CITY, 1895.



MATTRESS WEAVING, DIKE 16.





MATTRESS COMPLETE, READY FOR SINKING. DIKE 16.

Dates of ice closings and openings on the Missouri River above Sioux City, Iowa, 1895–96.

[Continued from page 2237 report for 1895.]

Locality.	Closing.	Opening.
Montana:		
Townsend	Nov. 7, 1895	Mar. 12, 1896
Great Falls	Nov. 18, 1895	Do.
Fort Benton	Nov. 22, 1895	Do.
Wolf Point	Nov. 7, 1895	Mar. 22, 1896
North Dakota:		
Fort Buford	Nov. 9, 1895	Mar. 26, 1896
Bismarck	Oct. 29, 1895	Mar. 29, 1896
South Dakota:		
Pierre	Nov. 25, 1895	Apr. 2, 1896
Running Water	.....do	Do.
Iowa:		
Sioux City	Nov. 29, 1895	Apr. 4, 1896

Z 2.

REMOVAL OF SNAGS AND OTHER OBSTRUCTIONS IN MISSOURI RIVER ABOVE SIOUX CITY, IOWA.

A description of the condition of the river above Sioux City is given in the report upon "Improvement of the upper Missouri between Stubbs Ferry in Montana and the lower limits of Sioux City, Iowa."

The approved project adopted contemplates the removal of snags and other obstructions from the Missouri River between Stubbs Ferry and the south limits of Sioux City. Three snag boats are maintained for the work which is done by hired labor.

APPROPRIATIONS.

March 3, 1893	$50,000
August 18, 1894	50,000
June 3, 1896	50,000

The snagging fleet available for the work above Sioux City consists of one steel hull snag boat, *James B. McPherson;* one wooden hull snag boat, *Josephine*, and one steel hull snag boat, *Mandan*, all fitted with steam propelling power. The boats were purchased or built from the appropriation for improving Missouri River above Sioux City, and their work forms part of the approved project for the general river improvement.

The work was done during favorable seasons since then. The funds have been provided by allotments from the appropriations for the river improvement and by special appropriations for the work.

The *Josephine* has been engaged since the adoption of the present project between Washburn and Fort Yates, N. Dak.; the *Mandan* between Fort Yates, N. Dak., and Chamberlain, S. Dak., and the *James B. McPherson* between Chamberlain, S. Dak., and Sioux City, Iowa.

Over this portion of the river the snags have been to a large extent removed from the existing channel, but the changes of the river are constantly uncovering new ones. Large numbers of rocks have yet to be taken out.

Summary of work of boats, July 1, 1895, to June 30, 1896.

Snag boat.	Snags removed.	Snags abandoned.	Trees cut.	Miscellaneous obstructions removed.	Miles run—	
					Up.	Down.
McPherson	366	.....	.....	299	345	672
Josephine	269	6	385	234	529	488
Mandan	149	3	131	78	329	467
Total	784	9	516	611	1,203	1,627

Money statement.

July 1, 1895, balance unexpended	$35,654.41
Received from refundment of overpayment	1.00
Amount appropriated by act of June 3, 1896	50,000.00
	85,655.41
June 30, 1896, amount expended during fiscal year	32,702.36
July 1, 1896, balance unexpended	52,953.05
July 1, 1896, outstanding liabilities	2,953.05
July 1, 1896, balance available	50,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	†60,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

Z 3.

IMPROVEMENT OF YELLOWSTONE RIVER, MONTANA AND NORTH DAKOTA.

APPROVED PROJECT.

The approved project contemplates rock removal at various places on the river, the closing of chutes by dams, and the construction of contracting dikes, and a survey of the river.

Operations under this project are now suspended.

APPROPRIATIONS.

1878 (allotment for surveys from appropriation for examination and surveys)	$15,000
1879	25,000
1880	15,000
1881	20,000
1882	20,000
1884	20,000
1886	18,750
1896	10,000

CONDITION AT BEGINNING OF YEAR.

The expenditures have resulted in giving a depth of 3 feet at points improved above Glendive, and of 3 feet or more at points improved below that place. The survey was finished.

OPERATIONS DURING THE YEAR.

During the fiscal year ending June 30, 1896, no work was done. For reasons given in Appendix X 2 of the Annual Report of the Chief of Engineers for 1887, the project was suspended for further action of Congress.

There has been expended on the improvement of the river a total sum of $103,029.59, and on the survey a total sum of $19,000.

There was formerly a brisk river traffic, which has been killed by the railroads.

The river and harbor act of June 3, 1896, appropriates the sum of $10,000 for continuing improvement, and directs that the money shall be expended at or near Glendive, Mont.

A project for the application of these funds has not yet been approved.

Money statement.

July 1, 1895, balance unexpended	$11,720.41
Amount appropriated by act of June 3, 1896	10,000.00
July 1, 1896, balance unexpended	†21,720.41

*Including $10,000 estimated for extraordinary repairs to hulls and machinery of snag boats.

†Includes balance of 41 cents deposited to the credit of the Treasurer of the United States as repayment to the appropriation, November 29, 1895.

APPENDIX A A.

IMPROVEMENT OF CUMBERLAND RIVER, TENNESSEE AND KENTUCKY, AND OF OBION AND FORKED DEER RIVERS, TENNESSEE.

REPORT OF CAPT. JOHN BIDDLE, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Obion River, Tennessee.
2. Forked Deer River, Tennessee.
3. Cumberland River, Tennessee and Kentucky.

ENGINEER OFFICE, UNITED STATES ARMY,
Nashville, Tenn., July 18, 1896.

GENERAL: I have the honor to transmit herewith the annual reports upon the river improvements in my charge for the fiscal year ending June 30, 1896.

Very respectfully, your obedient servant,

JOHN BIDDLE,
Captain, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

A A 1.

IMPROVEMENT OF OBION RIVER, TENNESSEE.

The Obion River flows wholly in the State of Tennessee, and is a tributary of the Mississippi River, which it enters near Hale Point, about 95 miles above Memphis.

This stream is formed by the junction of the North and South forks in the western part of Tennessee, and flows in a generally southwesterly direction for about 75 miles to the Mississippi. In its course the Obion receives the overflow from Reelfoot Lake, and about 3½ miles from its mouth the waters of the Forked Deer River. At the town of Obion, the river is crossed by the bridge of the Newport News and Mississippi Valley Railroad and by a highway bridge, which have no draws, and consequently form a barrier to navigation. Improvement would be practicable only to the junction of the forks, about 6 miles above the bridge.

An examination of this stream was made in 1880. (Report of the Chief of Engineers, 1881, pp. 1486–1489.) An instrumental survey was made in 1891 from the railroad bridge at Obion to the mouth of the

river, a distance of 68.8 miles, having a fall of 27 feet. (Report of Chief of Engineers, 1891, pp. 2296–2301.)

The course of the Obion is through a low, alluvial, and well-timbered country, subject to overflow, due in a great measure to backwater from the Mississippi. It has a width varying from 80 to 200 feet, and the banks being from 10 to 18 feet above low water; the depth in the pools is generally over 5 feet at low water, but at the shoals a depth of but 18 inches is often found. The shoals are in part caused by obstructing driftwood, which holds sediment in place. The removal of the drift in some cases will aid in the removal of the shoals. These would, however, probably re-form at other places. The backwater of the Mississippi also causes bars to form. The river has been greatly obstructed by snags and overhanging trees. The tortuous course is a source of difficulty, some of the bends being very sharp, forming loops with narrow necks. In some places cut-offs have been made, these being sometimes a disadvantage and at others an advantage. There was but little current before improvements were begun. It will increase, however, as the river is cleared.

As far back as 1843 surveys were made by the State of Tennessee, and considerable work done by the State in clearing the river of surface obstructions, but the advantages gained were but of temporary duration.

The project for the improvement, based upon the survey of 1891, and the estimate of $50,000, seeks to secure at low water a navigable channel of not less than 3 feet depth between Obion, Tenn., and mouth of river, about 68.8 miles, by clearing the channel of snags, drift, and overhanging trees; constructing wing dams at the most obstructive shoals; straightening the very crooked channel by cutting through several sharp bends and making the cut-offs sufficiently wide and deep by clearing, grubbing, and excavating; closing the old channel by means of pile and brush dams where necessary.

Practically all the work done on this river has been to remove drifts, snags, overhanging trees, etc. The only satisfactory method has been to do the work at extreme low water, cut the trees, limbs, snags, etc., into short pieces and either let them float off, or, if too heavy, drop them in deep holes. Dynamite has also been used to break up snags. Drifts and snags are of course constantly recurring, so that much of the river has had to be gone over again. The clearing of the river has already increased the current somewhat, thus lowering the water surface.

I do not consider it possible to obtain 3 feet at low water by the methods proposed in the project. If a clear channel, free from snags and trees, is obtained, it will be all that can be legitimately expected. This will, however, be fairly satisfactory on this river, as the Mississippi keeps it at a good stage for a great part of the year. The lower part of the stream especially is much affected by the Mississippi, and at the mouth is a shifting bar formed by the latter.

The following appropriations have been made for this work by Congress:

Act of—	
July 13, 1892	$7,500
August 17, 1894	7,500
June 3, 1896	6,000
Total	21,000

The amount expended, including outstanding indebtedness to close of the fiscal year ending June 30, 1895, was $11,423.33, which has resulted

in opening up the river and in obtaining comparatively safe navigation to Obion, Tenn. In May, 1893, a small steamboat with two loaded barges passed up from the lumber mill near Lane Ferry to Obion, about 22 miles, being the first steamboat to reach that town in fifty years. The channel has been greatly improved by the removal of surface obstructions, principally drift. Operations in channel were begun on October 17, 1892, and continued until December 21, 1892, and were resumed on September 25, 1894, and continued until February 23, 1895; and again resumed April 22, and closed May 28, 1895. A small steamboat was profitably employed in snagging from January 11 to February 7, 1895. All work was carried on by hired labor, the method most economical and advantageous to the Government.

During the present fiscal year a small force was employed in channel work, from August to December, between Obion, Tenn., and a point about 10 miles from mouth of river.

The following work was done by hired labor, the method most economical and advantageous to the Government, viz, 1,766 snags, 384 logs, 109 stumps, and 190 cords of drift removed from channel; 603 leaning trees cut down, 34 trees deadened and topped, and 193 logs pinned to banks to prevent their being carried into the channel at flood stages. In February, 1896, it was found necessary to do some work in the reach of about 20 miles of river immediately below Obion, in order to maintain the channel in a safe navigable condition; 194 snags, 5 logs, and 78 cords of drift were removed; 66 snags and trees topped, and 123 leaning trees cut down.

The amount expended, including outstanding indebtedness, during the fiscal year was $2,885.85.

The commerce of this river is principally lumber, cut by sawmills now in operation on or near this stream, and so far as can be ascertained the improvements have given material aid to the lumber interests involved. The product of these sawmills on the Obion River goes to all points on the Mississippi River, and as no record is kept of shipments by river, it is impracticable to get data of the same. It is reported that the first shipment of corn by river was made from Lane Ferry during the present fiscal year.

Estimate of cost of improving Obion River, Tennessee	$50,000.00
Amount appropriated	21,000.00
Amount expended, including outstanding indebtedness	14,276.88

The above estimated amount is wholly inadequate to produce the results called for in the existing project, viz, to obtain 3-foot navigation at low water by means of open-channel work; it is doubtful if this result can be obtained at all by that method. A modification of the project during the next fiscal year will be submitted in which the revision of the estimate and probable cost of maintenance will have consideration.

Money statement.

July 1, 1895, balance unexpended	$3,608.97
Amount appropriated by act of June 3, 1896	6,000.00
	9,608.97
June 30, 1896, amount expended during fiscal year	2,865.85
July 1, 1896, balance unexpended	6,743.12
July 1, 1896, outstanding liabilities	20.00
July 1, 1896, balance available	6,723.12
Amount that can be profitably expended in fiscal year ending June 30, 1898 Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	10,000.00

COMMERCIAL STATISTICS.

Obion River, Tennessee, from July 1, 1895, to June 30, 1896.

Articles.	Tons.	Estimated value.
Corn	980	.....
Lumber	34,600	.....
Logs	31,000	.....
Spokes	35	.....
Total	66,615	$35,260

List of steamboats (stern-wheel) plying on Obion River, Tennessee.

Name.	Length.	Breadth.	Depth.	Tonnage
	Feet.	*Feet.*	*Feet.*	
Clyde	50	14	2.5	10.
Gracie	52	11	4.6	34.79
James Laughlin	71.5	15	4.5	28.76

A A 2.

IMPROVEMENT OF FORKED DEER RIVER, TENNESSEE.

I. The Forked Deer River and its navigable branches run wholly in the State of Tennessee, and are tributary to the Mississippi system. The main stream, about 21 miles long, is formed by the junction of the North Fork and South Fork, about 8½ miles below Dyersburg, Tenn., thence flowing southwesterly enters the Obion River, about 3½ miles above its mouth, the latter stream entering the Mississippi River at Hale Point, about 95 miles above Memphis. Formerly the Forked Deer River entered the Mississippi direct, through two channels, between Island No. 26 and Ashport, about 18 miles below the present mouth of the Obion River. These outlets, now called Lost and Old channels, are nearly filled up by snags and drift, but water flows through them during high-water stages in the Mississippi River. About fifty years ago the State of Tennessee cut a canal, know as Tiger Tail, about three-fourths of a mile long, which shut off the former outlet, so that now the Forked Deer empties into the Obion River about 3½ miles above its mouth, and the combined stream flows through an old bed of the Mississippi to the present junction with the latter. The Forked Deer River was shortened about one-half by this canal.

The North Fork rises in Gibson County, and the Middle Fork in Carroll County. These streams unite about 15 miles above Dyersburg, thence, flowing westerly under the name of either North Fork or Middle Fork past that town, joins the South Fork 8½ miles below, thus forming the main stream of the Forked Deer River.

The South Fork rises in McNairy County and flows in a general southeasterly direction for about 250 miles. Jackson, about 148 miles above its junction with the North Fork, is held to be the head of navigation. The stream for some distance below Jackson is very small.

Examinations of these streams have been made as follows:

1. *Of the North Fork and Forked Deer River.*—From Dyersburg to mouth of the main stream, distance about 29½ miles, made in 1873 under act of March 3, 1873. (Report Chief of Engineers, 1874, Part I, pp. 372–380.)

2. *Of the South Fork.*—From Jackson to junction with North Fork, distance about 149 miles; of the North Fork, from Collins to the mouth of Forked Deer River, main stream, distance about 131 miles, each made in 1880 under act of June 14, 1880. (Report Chief of Engineers, 1881, pp. 1489–1497.)

3. Of the North Fork below Dyersburg, Tenn.—Preliminary examination made in 1886 under act of August 5, 1886. (Report Chief of Engineers, 1887, pp. 1494–1495.)

4. Of the Forked Deer River.—From Dyersburg, Tenn., to its junction with the Obion River and thence to the Mississippi River, made in October, 1894, act of August 17, 1894. (Report Chief of Engineers, 1895, pp. 2265–2275.)

By act of June 3, 1896, provision was made for a survey of the North Fork of Forked Deer River from Dyersburg, Tenn., to the Mississippi River, 33 miles. This survey is not yet begun.

The navigable channel way throughout its entire length from Dyersburg, Tenn., to the Mississippi River was in its original condition greatly obstructed by snags, embedded logs, leaning trees, and large accumulations of drift, the upper sections of the North Fork and South Fork being very crooked and the bends short and numerous. The North Fork, 8½ miles, averages about 65 feet in width, and from the junction of the North and South Forks to Key Corner, the last highland on the main river, 11½ miles, the river widens to from 150 to 200 feet, though at several sharp bends it is narrowed to 80 or 100 feet, the channel, however, at these points being generally clear and deep and the banks are uniform and unbroken, showing but little erosion, the fall in 20 miles is 6.58 feet. From Key Corner to the Obion River, 9½ miles, with a fall of 15.77 feet, the river flows through the Mississippi bottom lands, shoaling rapidly and being very crooked; the banks are high but alluvial, and therefore subject to heavy erosion; from the mouth of the Forked Deer River to mouth of the Obion River, Tennessee, 3½ miles, with a fall of 4.20 feet, channel width from 60 to 100 feet, but very deep. The bars at the mouths of the Forked Deer and the Obion form the principal obstructions to navigation on this section.

The original project for the improvement of the South Fork provides for the removal of surface obstructions, so as to give greater ease and safety to navigation between the junction of the North and South Forks and Brownsville Landing, an estimated distance of about 73 miles. This project was modified in 1883, so as to extend operations in channel to Jackson, Tenn., about 75 miles.

The project for improving the North Fork and the main stream under the general head of Forked Deer River provided for the same class of channel work as was found necessary in the South Fork.

In 1891 (Report Chief of Engineers, p. 2013) the engineer officer then in charge reported that in his opinion the only work to be done could be completed with an additional appropriation of $3,000, which was made for "completing improvement" by act of July 13, 1892. The originally adopted project, as amended in 1891, is therefore to that extent completed, and consequently there was not at the close of the fiscal year any existing approved project for improving the Forked Deer River and its navigable branches.

The appropriations made have been as follows:

By acts of—	
August 2, 1882, for South Fork	$3,000
July 5, 1884, for South Fork	2,000
August 5, 1886, for South Fork	5,000
August 11, 1888, for South Fork	2,500
August 11, 1888, for North Fork	4,500
August 11, 1888, for main river	2,500
September 19, 1890, for North Fork and main river	2,500
July 13, 1892, for Forked Deer River (completing improvement)	3,000
Total, to complete project	25,000
June 3, 1896, for Forked Deer River (for maintenance)	1,000
June 3, 1896, for North or Middle Fork, from Dyersburg to Mississippi River	5,000
Total appropriated	31,000

The amount expended to June 30, 1895, was $24,896.25. Upon the South Fork, $12,500; upon the North Fork and main river, $12,396.25. These expenditures resulted in putting the North and South Forks in fairly good, navigable condition. The removal of surface obstructions from the main stream below the junction of the Forks has enabled small boats to navigate it with greater ease and safety during a period of about eight months of each year.

On the South Fork the channel has been improved from Jackson to its junction with the North Fork. It is stated that before the improvement was begun, in July, 1883, about one flatboat in three was lost by reason of obstructions in the channel, but that after the improvement boats could make trips in comparative safety and at less cost. Until this summer all through navigation was prevented by the Louisville and Nashville Railroad Bridge at Bells. There has been practically no navigation on the South Fork above Chestnut Bluff (about 10 miles above junction) since the improvement. It is probable that the river has filled up considerably with logs and snags.

On the North Fork the work below Dyersburg was begun in October, 1888, and has enabled boats to run at a stage of water about 3 feet lower than formerly.

On the North Fork and main stream during active operations in 1888 and 1889 a hand-propelled snag boat, fitted with light shears and steam power, was used to good advantage. In 1891 a United States snag boat did effective work by removing surface obstructions, and in 1894 a pile-driver barge, fitted up with "quarters" and a hand capstan on each end, was towed from Memphis into the North Fork, which was thoroughly cleared, the chief obstructions being snags and sunken logs; many of the latter were from 2½ to 5 feet in diameter and from 8 to 30 feet long. These were hauled out and destroyed by explosives. Channel work was suspended July 7, 1894, the available funds being nearly exhausted.

All work has been carried on by hired labor, the method most economical and advantageous to the Government; in fact the only practicable method.

The amount expended during the present fiscal year was $87.99 in disbursements on account of storage of engineer property and expenses pertaining to inspection of bridges and service of notice, etc., required in such cases.

The opinion is again expressed, as stated in Report of the Chief of Engineers, 1895, p. 2249, that no satisfactory channel can be obtained on the Forked Deer River all the year by means of open-channel work, and that the cost of a slack-water system of navigation, with lifts not to exceed 6 or 7 feet, will reach $400,000 and be very expensive to maintain. The expenditure of about $1,000 yearly can be profitably made in the maintenance of safe navigation in the channel of the Forked Deer River and its two main branches.

An appropriation of $1,000 was made by act of June 3, 1896, for improving Forked Deer River, Tennessee, for maintenance. If approved as projected this sum can be most profitably expended in work upon the South Fork Channel, as the channel of the North Fork and main stream is provided for in another item of appropriation in said bill, viz: "For improving the North or Middle Fork of Forked Deer River, Tennessee, from Dyersburg to the Obion, and from thence to the Mississippi River."

The commerce of this stream, so far as can be ascertained, consists almost wholly of logs, lumber, and timber products moved in rafts or flatboats.

The benefits derived from the improvements are somewhat indefinite. There is no doubt but that new timber lands have been opened up and a certain amount of local navigation developed, mostly carrying logs to mills and carrying off the sawed lumber.

The A. M. Stevens Lumber Company, of Dyersburg, Tenn., doing business largely on the North Fork and main river, reports great benefits from the improvements. The owner of the steamer *Mary Louisa*, on the contrary, considers the improvements of but little good. He states that he has no freight tonnage to report as required by law, and has done practically no work for over a year by reason mainly of the character of the bridges crossing the South Fork.

The bridge operated by the Louisville and Nashville Railroad over the South Fork at Bells, Tenn., has been modified during the year by direction of the Secretary of War, so as to secure a clear navigation span of 50 feet at the low-water line and the removal of all piles from the channel to 3 feet below low water, thus providing for the safe passage of rafts and flatboats propelled by hand. It is thought that this will satisfy all the reasonable demands of commerce for some years to come above Bells, as this commerce, if any, will consist of logs and lumber.

The draw of the bridge operated by the Chesapeake, Ohio and Southwestern Railroad at South Fork was closed for some time, but complaint having been made the draw was again placed in condition to be readily opened for the passage of steamboats, etc., when demanded.

Original estimates for improving North and South forks and main stream of the Forked Deer River	$30,750.00
Amount appropriated, including act of September 19, 1890	22,000.00
Estimate submitted to complete existing project (Report of Chief of Engineers, 1891, p. 2014)	3,000.00
Amount appropriated, act of July 13, 1892	3,000.00
Total amount appropriated to complete existing project	25,000.00
Amount expended	24,984.24

Money statement.

July 1, 1895, balance unexpended	$103.75
Amount appropriated by act of June 3, 1896	1,000.00
	1,103.75
June 30, 1896, amount expended during fiscal year	87.99
July 1, 1896, balance unexpended	1,015.76
Amount that can be profitably expended in fiscal year ending June 30, 1898, for maintenance	1,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

II.—*The North or Middle Fork of Forked Deer River, Tennessee, from Dyersburg to the Obion River, and from thence to the Mississippi River.*—The stream from Dyersburg, Tenn., to the Mississippi River, about 33 miles, is locally known as the North Fork from Dyersburg, Tenn., to its junction with the South Fork, 8½ miles; thence to the Obion River as the Forked Deer River, main stream, 21 miles; thence to the Mississippi River as the Obion River, 3½ miles, and has been heretofore so provided for under sundry appropriations.

A survey was made of this stream from Dyersburg to the Mississippi River in 1894, and report submitted that the stream can not be made

navigable "all the year by means of open-channel work," consequently no estimate nor project was made for such work. The general estimate of $400,000 was given in said report for a slack-water system of navigation. (Report of Chief of Engineers, 1895, pp. 2265–2275.)

By act of June 3, 1896, $5,000 is appropriated for improving the stream from Dyersburg, Tenn., to the Mississippi River under the general name of the North or Middle Fork of the Forked Deer River, for removing bars and shoals, deepening the channel, and improving the navigation of said river; that is, channel work generally.

The project for its expenditure, if approved, will be applied, as provided in the act, to clearing the channel of surface obstructions, reducing bars and shoals, so as to deepen the channel and make it navigable for small craft at a 3-foot stage from Dyersburg to the mouth of Obion River. The section of 3½ miles from the mouth of the Forked Deer River to the Mississippi River is provided for in said river and harbor act in the item of appropriation ($6,000) for "improving Obion River, Tennessee."

The commerce to be benefited is to a large extent identically the same as that hereinbefore reported.

A survey with estimate of the cost of improvement, at the discretion of the Secretary of War, is directed to be made of this stream from Dyersburg to the Mississippi River, by act of June 3, 1896, setting forth in detail the obstructions to be specially considered. When report of such survey is submitted the estimate accompanying may then form the basis of cost of the whole work projected, and, being ascertained, the $5,000 now appropriated may be held to form a part of said project and estimate.

Money statement.

Amount appropriated by act of June 3, 1896	$5,000.00
July 1, 1896, balance unexpended	5,000.00

COMMERCIAL STATISTICS.

Forked Deer River, Tennessee, from July 1, 1895, to June 30, 1896.

Articles.	Tons.	Estimated value.
Lumber	62,000	$32,000
Logs	42,000	8,000
General merchandise	10	1,000
Total	104,010	41,000

NOTE.—The above statement is of the business of the steamer *James Laughlin*, with four barges; ten trips between Dyersburg, Tenn., on the North Fork, and Key Corner, on main stream; also carried 50 passengers. Twenty trips between Dyersburg, Tenn., and Band Mill, on the Obion River.

List of steamboats navigating Forked Deer River, Tennessee.

Name.	Length.	Breadth.	Depth.	Tonnage.
	Feet.	*Feet.*	*Feet.*	
James Laughlin	71.5	15	4.5	28.76
Mary Louisa	51	16	3	39.90

A A 3.

IMPROVEMENT OF CUMBERLAND RIVER, TENNESSEE AND KENTUCKY.

The Cumberland River rises in eastern Kentucky, on the western slope of the Cumberland Mountains; flows in a tortuous course of about 688 miles through eastern Kentucky, middle Tennessee, and western Kentucky, and discharges into the Ohio River near Smithland, Ky. From Point Burnside, Ky., the head of steamboat navigation, to Smithland, Ky., the distance is 518 miles by the river, 203 miles being in the State of Kentucky and 315 miles in the State of Tennessee.

From 1830 to 1840 the legislatures of Tennessee and Kentucky made several appropriations for the improvement of the navigation of the Cumberland River, but little benefit to the general condition of the river seems to have been accomplished. The Cumberland Navigation Company was incorporated by the State of Tennessee in 1846, for improving the "navigation of the Cumberland River below the town of Nashville by means of a system of locks and dams," but nothing tangible was done to carry out the proposed improvement.

Congress appropriated $155,000 for improving the river by acts of—

July 17, 1832	$30,000
June 28, 1834	30,000
July 7, 1836	20,000
March 3, 1837	55,000
July 7, 1838	20,000
Total	155,000

The funds were expended in carrying out the project authorized by act of Congress and based on the survey of Capt. Howard Stanbury, $20,000 being applied below Nashville and $135,000 upon the general river.

The following examinations and surveys have been made:

(1) Reconnaissance from the Great Falls of the Cumberland River to Nashville; thence survey to its mouth at Smithland, Ky., made under act of July 11, 1870. (Reports Chief of Engineers, 1871, pp. 468–485, and 1872, pp. 463–472.) This survey, with accompanying estimates of $248,821, which were increased in 1888 to $498,000, forms the basis of the project under which the work below Nashville was carried on from 1871 to 1889—that is, until the adoption of the existing project for the canalization of the lower river. The work from Nashville to Smith Shoals was carried on under the project of 1871 until 1887.

(2) A survey of Smith Shoals made in 1874 (Report of Chief of Engineers, 1875, pp. 795–800) was the basis of the project of work at that obstruction from 1877 to 1883.

(3) Survey of the Falls of the Cumberland River made in 1878. (Report of Chief of Engineers, 1879, pp. 1279–1282.)

(4) Reconnaissance of the country bordering on the Cumberland River above the Falls, made in October and November, 1880, being supplementary to the report on the survey of the Falls of the Cumberland. (Report Chief of Engineers, 1881, pp. 1854–1859.)

(5) Survey from the head of Smith Shoals to Nashville was made under act of August 2, 1882. (Report Chief of Engineers, 1884, pp. 1663–1675.) On this survey is based the project of improvement by locks and dams, above Nashville.

(6) Survey of the "Lower Cumberland River from Nashville to its mouth to ascertain if necessary to establish locks and dams." (Report

of Chief of Engineers, 1890, pp. 2151–2161.) On this survey and estimates is based the existing project for channel work and extending to the lower river the system of lockage begun above Nashville.

The obstructions in the Cumberland River are of a uniform character, consisting of rock ledges, sand and gravel bars, bowlders, snags, overhanging trees, and other surface obstructions. The Cumberland River supplies in many cases, both above and below Nashville, the only means of transit between the towns and villages lying along its course.

The seventeen appropriations made by Congress for the Cumberland River from 1871 to 1896, amounting in the aggregate to $1,796,000, are hereinafter itemized under the heads of "Below Nashville," and "Above Nashville."

1. BELOW NASHVILLE (191 MILES).

The Cumberland River below Nashville is usually navigable for all steamboats plying on it for six months in each year; for boats not drawing over 3 feet, from six to eight months; and for boats drawing 16 inches or less, for the whole year. Navigation is practically closed for several months each year during low water.

The original project provides for channel work as follows:

To excavate the bars and rock ledges to get an additional depth of water, to contract the waterways in places to get the requisite depth, to remove snags and bowlders from the main channel, and to restrain tributary streams in well-determined channels at their junction with the river.

To increase the depth of water at the shoals at the junction of the Cumberland River with the Ohio River, a Board of Engineer Officers recommended the construction of a dike near Smithland, Ky., at an estimated cost of $129,600. (Report of Chief of Engineers, 1888, pp. 1626–1632.) The river and harbor act of September 19, 1890, allotted $30,000 from the appropriation for improving Cumberland River below Nashville, to be expended in improving the mouth of the river as recommended.

Under the old project and estimates the following appropriations have been made for the section of the river below Nashville:

Act of—		Act of—	
March 3, 1871	$30,000	August 5, 1882	$15,000
June 10, 1872	20,000	July 5, 1884	7,500
March 3, 1873	25,000	August 5, 1886	12,500
March 3, 1875	25,000	August 11, 1888	10,000
June 18, 1878	45,000	September 19, 1890	40,000
March 3, 1879	40,000		
June 14, 1880	20,000	Total	305,000
March 3, 1881	15,000		

The existing project for improving the river below Nashville consists of (1) the extension of the lock and dam system of the Upper Cumberland to the lower river by the construction of 7 locks and dams, extending from near the mouth of Harpeth River (Lock A) to Big Eddy Shoals (Lock G), the lock chamber to be each 280 feet available length by 52 feet width, the lifts of the locks varying from 8½ to 11½ feet, aggregating about 70 feet; (2) of the improvement of the Kentucky Chute at mouth of river, as recommended by Board of Engineer Officers June 16, 1888 (Report of Chief of Engineers, 1888, p. 1628); (3) of the channel work necessary below Lock G, between Big Eddy Shoals and mouth of river; and (4) snagging and removal of surface obstructions below Nashville. Total estimate of cost of entire improvement, $1,964,500. (Report of Chief of Engineers, 1890, pp. 2151–2161.)

The following appropriations have been made under this project and estimate:

Act of—	
July 13, 1892	$40,000
August 17, 1894	30,000
June 3, 1896	80,000
Total	150,000

The act of July 13, 1892, appropriated $40,000 for continuing the improvement, including the mouth of the river, and "that $10,000 of this sum, or so much thereof as may be necessary, shall be available for acquiring site and locating lock and dam near the mouth of Harpeth River, Tennessee." This provision forms the initial appropriation for operations under the project or plan as above stated, viz:

Lock and dam system from near mouth of Harpeth River (Lock A) to Big Eddy Shoals (Lock G), 107 miles.

Channel work between Big Eddy Shoals and mouth of river, 43 miles.

The total amount expended to June 30, 1895, was $330,250.39; of which $304,008.88 was expended on account of old project, and $26,241.51 on account of new project.

The appropriations for the old projects amounted to $305,000, which were increased $18.08 by special Treasury settlement with Quartermaster's Department, March 17, 1891, thus making the sum drawn on requisitions		$305,018.08
Expended June 30, 1895	$304,008.88	
Expended fiscal year 1896	1,009.20	
		305,018.08

as hereinafter stated.

The expenditure under the old project has resulted in lengthening the season of navigation by giving an increased depth at low water, combined with greater security in the passage of obstructions; improvements more or less complete being effected in the river at Harpeth Shoals, Palmyra Bar, Elk Creek Shoals, Dover Shoals, Big Eddy Shoals, etc., by clearing channel of surface obstructions, the work being carried on by hired labor. At mouth of river a pile dike was constructed and riprap protection placed on shore of Cumberland Island and banks above foot of island opposite the Kentucky mainland under contract, which contract was completed in July, 1893. The dike in its present condition is not complete as recommended in the project above mentioned of the Board of Engineers. This project called for a pile dike surmounted with crib work. Sufficient funds were allotted to put in only the pile work, and the works for the protection of Cumberland Island opposite the dike. Moreover, in laying out the dike it was found that the towhead along which the dike was built projected within the line of the dike and to the full height of the piles for a length of several hundred feet. This portion was therefore not touched and forms a gap in the pile work.

The dike as at present constructed, however, secures the object sought after, that is, the passage from the Cumberland River to the Ohio. Bars form in the Ohio River opposite the mouth beyond the end of the dike. These bars shift continually, but there has never been any difficulty in passing from one river to the other since the dike has been completed, while previously the mouth was often closed while each river remained navigable. It seems probable that some time the gap in the dike will have to be protected. With that in view and also to ascertain effect of dike, surveys have been made each year to determine the changes that occur. Up to the present no cutting of the towhead has

taken place. It is suggested that if this happens it would be well to cover the gap with a layer several feet thick of broken stone extended in front of the line of the dike, so that as the bank cuts away the stone will fall in and make a protection. It is also possible that Cumberland Island will have to be further protected.

The present condition is, however, that for an expenditure of $23,716.71 the results sought for under a project estimated at $129,600 have been obtained.

The Harpeth Shoals form the most formidable obstruction to the navigation of the Lower Cumberland, and to overcome this obstacle the existing project has in view that Lock and Dam A be begun and pressed to completion as soon as practicable.

Under the new or existing project the sites for lock and abutment of Dam A, 15.9 acres, about 2½ miles below the mouth of Harpeth River and about 41½ miles below Nashville, have been purchased and title vested in the United States; the erection of temporary buildings at lock site begun; well dug for use of employees; incline graded; machinery set up, and other necessary preparations perfected in order to begin work of building cofferdam, excavating foundation of lock-chamber, etc.

During the present fiscal year the lock site, right of way, and bank at lock approaches have been cleared; temporary buildings finished; cofferdam, 700 feet long, completed in October, 1895, and riprap protection placed at junction of dam and bank; 103 cubic yards of rock and 3,892 cubic yards of sand and gravel excavated for foundation of lock, all of the excavation which is advisable to be done prior to the laying of masonry. The appropriation of June 3, 1896, will allow the masonry to be begun, but not completed.

In July the dams at mouth of river were examined to ascertain their condition and that of the channel. In September the old dam running out from the upper end of Cumberland Island was partly taken out, 70 cubic yards of stone, 3 logs, and 1 sunken barge removed from channel. In October stones were cut and placed in position for marking boundary of United States lands. In November and December some work in the channel near Nashville and the Davidson County bridge was finished; 300 logs, 250 cubic yards of loose material, and a drift pile 50 by 50 by 20 feet were removed. The U. S. steamer *John Phœnix* was painted and other minor repairs made. The building of a new hull for the steam snag boat was begun in February and finished in May, 1896. All work was carried on by hired labor, the method most economical and advantageous to the Government.

The high water of the spring of 1896 has been especially disastrous to the banks of the Cumberland River. Numerous slides of great extent have taken place, amounting both in number and size to more than have occurred in the previous ten or fifteen years combined. Scarcely a mile of the river but has more than one slide, and in some cases blocks of earth several hundred feet long have slipped bodily into the stream.

These slides are not common on the Cumberland where the banks are usually good and permanent. It shows, however, what precautions must be taken in building the locks. The only reason that can account for this year's unusual damage is that a period of rather prolonged high water was followed by a very rapid falling of the river, and the back water probably pressed out the banks.

The covering of the bank, whether by trees, brush, or grass, does not seem to have had any influence. The points of slipping were probably determined by the nature of the soil.

The amount expended during the fiscal year ending June 30, 1896, including outstanding indebtedness, was $18,365.49, divided as follows:

At mouth of river, act of September 19, 1890	$1,009.20
General improvement: Channel work and contingencies	3,574.50
Lock and abutment of Dam A	13,781.79
Total	18,365.49
The estimate of cost of improving Cumberland River below Nashville, in accordance with revised and existing project of 1889	1,964,500.00
Amount appropriated under existing project	150,000.00
Amount expended under existing project, including outstanding indebtedness	43,597.80

The cost of maintenance of the river below Nashville in its present condition is estimated at about $5,000 per annum. As each lock is completed the cost will be increased from $4,000 to $6,000 per lock. When the whole system of six locks is completed, including the channel work to be done each year below the locks, and to maintain connection with the Ohio River, the probable cost of maintenance will be about $50,000 per annum.

Money statement.

July 1, 1895, balance unexpended	$44,767.69
Amount appropriated by act of June 3, 1896	80,000.00
	124,767.69
June 30, 1896, amount expended during fiscal year	17,916.63
July 1, 1896, balance unexpended	106,851.06
July 1, 1896, outstanding liabilities	448.86
July 1, 1896, balance available	106,402.20
Amount (estimated) required for completion of existing project	1,814,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	500,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

2. ABOVE NASHVILLE (497 MILES), FROM NASHVILLE TO CUMBERLAND FORD.

The Cumberland River is navigable usually from Nashville to Point Burnside, Ky., 327 miles, for steamboats drawing not more than 3 feet, from four to six months of each year, and for boats of greater draft from two to three months. The fall is 223 feet, or about 18 inches per mile.

From Nashville to Caney Fork River (Carthage, 116 miles), the river is navigable for steamboats of 2½ feet draft from six to eight months, and for those of greater draft four or five months. Steamboats of light draft can ascend to Burkesville, 236 miles above Nashville, for from five to seven months, and larger boats four or five months.

The obstructions in the river above Nashville are of the same general character throughout, consisting of ledges, gravel and sand bars, bowlders, snags, overhanging trees, and rapid currents, and of mill dams in the section of the river above the mouth of Jellico Creek.

About 50 miles above Burnside, Ky., are the Great Falls of the Cumberland, a vast barrier to navigation, the difference of level between crest and foot of main fall alone being about 54 feet. Smith Shoals,

extending 10 miles above Burnside, Ky., having a fall of 55 feet in 8½ miles, form the most serious obstacle to navigation below the Great Falls.

The appropriations made by Congress for improving the Cumberland River above Nashville, under the original projects, were divided by years and geographical divisions as follows:

Geographical division.	Acts of—			
	Aug. 14, 1876.	June 18, 1878.	Mar. 3, 1879.	June 14, 1880.
1. Nashville to Kentucky line	$15,000	$20,000	$18,000	$15,000
2. Kentucky line to Smith Shoals	10,000	8,000	6,000	10,000
3. Smith Shoals	25,000	30,000	15,000	20,000
4. Smith Shoals to Falls of Cumberland	2,000	2,000	.....	.....
Total	52,000	60,000	39,000	45,000

Geographical division.	Acts of—			
	Mar. 3, 1881.	Aug. 2, 1882.	July 5, 1884.	Total.
1. Nashville to Kentucky line	$15,000	.....	.....	$83,000
2. Kentucky line to Smith Shoals	15,000	.....	.....	49,000
3. Smith Shoals	10,000	$15,000	.....	115,000
4. Smith Shoals to Falls of Cumberland	.....	.....	.....	4,000
5. Above mouth of Jellico, Ky	10,000	5,000	.....	15,000
6. Nashville to Smith Shoals	.....	30,000	.....	30,000
7. Nashville to head of Smith Shoals	.....	.....	$50,000	50,000
Total	50,000	50,000	50,000	346,000

These appropriations, aggregating the sum of $346,000, have been expended in the several sections as designated, excepting the sum of $5,000, originally appropriated by act of August 2, 1882, for the section "above the mouth of Jellico, Kentucky," but which was made available by act of September 19, 1890, for expenditure and "to be applied to the removal of snags and sand bars in the said Cumberland River above Nashville, Tenn.," and which has been so expended.

The disbursements incident to the works above Nashville under the above-named appropriations were from March, 1877, to December, 1887, and the work done consisted of clearing the channel of snags and other surface obstructions, in deepening the channel by excavation over the worst shoals, and the construction of wing dams, and has resulted in obtaining an increased depth at several of the principal obstructions, and thus securing each year a longer and safer period of navigation.

FROM NASHVILLE TO THE HEAD OF SMITH SHOALS, MOUTH OF ROCKCASTLE RIVER, 357 MILES.

The instrumental surveys of 1882 and 1883, with accompanying estimates (Report of Chief of Engineers, 1884, p. 1663 et seq.), furnish the basis of the present project for the radical improvement of the Cumberland River above Nashville. The project was modified by the adoption of larger locks than were first recommended and the estimates revised. (Report of Chief of Engineers, 1891, p. 2270.)

The original project provided for the construction of 23 locks and dams between Nashville, Tenn., and Burnside, Ky., and of 7 locks and 2 dams at Smith Shoals, using the river itself as a canal, 1 dam at Mill Shoals and the other at or near Shadowen Shoals, at an estimated cost of $4,077,922. This project provided that the 23 locks between Nashville, Tenn., and Burnside, Ky., "should be about 60 feet wide and 250 feet between miter sills, though perhaps smaller dimensions would answer the purpose" (Report Chief of Engineers, 1884, p. 1664), and that the dimensions of the 7 locks at Smith Shoals were to be "55 by 140 feet in the chamber." (Report Chief of Engineers, 1882, p. 1864.)

The above project as modified, or the existing project with the revised estimate, provides for the radical improvement of the river from Nashville to the head of Smith Shoals, mouth of Rockcastle River, Kentucky, 357 miles, by a complete system of lockage, consisting of 30 locks and dams, if this number be necessary, 23 below Burnside, Ky., and 7 above that point (the Smith Shoals system), with a view to secure a minimum channel depth of 6 feet, locks to be 280 feet long, 52 feet wide, and from 10 to 12 feet lift; provision also being made for clearing the channel from time to time of snags, drift, etc., brought down at flood stages, and for repairing and extending old dams and building new dams where necessary to maintain the improved condition of the river already secured by open channel work.

The appropriations made for work under the present project from Nashville to the head of Smith Shoals, mouth of Rockcastle River, are as follows:

Act of—		Act of—	
August 5, 1886	$75,000	August 17, 1894	$200,000
August 11, 1888	200,000	June 3, 1896	20,000
September 19, 1890	250,000		
July 13, 1892	250,000	Total	995,000

The act of August 5, 1886, specifically provided for this work of canalization "with a view to secure in the channel a depth of 4 feet, commencing with the lock at or near the lower island at Nashville." The Board of Engineer Officers constituted to examine and report upon the plan and estimate for No. 1 recommended a lock of the following dimensions: 280 feet long, 52 feet wide, from 10 to 12 feet lift, with 4 feet of water on lower and 5 feet on upper miter sill. This recommendation was approved by the Chief of Engineers and the Secretary of War. (See Report of Chief of Engineers, 1888, p. 1622 et seq.)

The plans first submitted provided for a lock (No. 1), fixed dam, and abutment of such dam, but upon further consideration by a Board of Engineers it was recommended conditionally and approved that a movable dam be constructed instead of a fixed dam. (See Report Chief of Engineers, 1890, p. 2143 et seq.) This Board in a subsequent report, dated November 26, 1890, for reasons therein given, withdrew its former suggestion and recommended the construction of a fixed dam as originally proposed.

The style of dam being thus determined, new plans for Lock No. 1, with a lift of 9 feet, and providing for a depth of water of 4 feet on the lower and 6½ feet on the upper miter sill, and for a fixed dam and abutment, were submitted to the Chief of Engineers and by him referred to the Board of Engineer Officers, who, in their report of April 20, 1891, recommended the plans for approval; the report of the Board being approved by the Secretary of War April 25, 1891, the plan for Lock No. 1 submitted being "almost identical with the * * * plans for Lock No. 2." (Report of Chief of Engineers, 1891, p. 2280 et seq.)

The Board of Engineers constituted to examine and report upon the plan and general design of Lock 2 recommended in their report November 25, 1890 (6727, 1890), a lock conforming to the dimensions prescribed for Lock 1, but recommending a depth of 6½ feet of water on the upper miter sill, and thus to provide for a minimum navigation of 6 feet instead of 4 feet, because "this can be done without extra cost" and is "necessary for the economical transportation of coal."

The plan for Lock 2, as approved, shows a uniform depth of 6½ feet of water on the sills, with a lift of 11 feet.

Congress provided that of the amounts appropriated by acts of July 13, 1892, and August 17, 1894, for improving Cumberland River above

Nashville, $10,000 "may be used, in the discretion of the Secretary of War, in the improvement of the river above the town of Burnside." It was recommended and approved that this sum ($5,000 from each of the above-named appropriations) be expended on the Smith Shoals system of lockage—that is, "be applied to continuing the work projected immediately above Burnside at Smith Shoals."

The amount expended, including outstanding indebtedness, to the close of the fiscal year ending June 30, 1895, was $761,932.07, of which sum $15,743.58 were expended on the Smith Shoals section.

This expenditure has been applied to the examination for sites of locks and abutments of Dams Nos. 1 to 8 and 21 and 22, inclusive, and of Locks Nos. 1 to 6 of the Smith Shoals series; purchases of sites for locks and abutments of Dams Nos. 1 to 6, inclusive; construction of masonry of lock and abutment of Dam No. 1 and lock keeper's house at Lock 1, under contracts; building cofferdam and in payments in settlement of contract discontinued and terminated for building Lock 2 at the old site; clearing sites, erecting temporary buildings, building cofferdams, etc., at Locks 2 (new site), 3, 4, and 5; completing masonry of walls of Locks 3 and 4; beginning excavation of foundation of Lock 5. Only the abutment of Dam 1 has been built. Bought dredge boat and built new hull for same; changed U. S. snag boat *Weitzel* into towboat and refitted her with new, powerful machinery, etc., suitable for heavy towage; built the tender *John Phœnix* for use in surveys. etc., and towboat *Susette* for use in work of lock construction; built 6 large decked stone barges for moving stone, etc., to and from lock sites; cleared channel of surface obstructions below Burnside, Ky., reducing rock ledges and gravel bars; repairing and extending riprap dams at Fishing Creek Shoals and Forbush Shoals, a few miles below Burnside, Ky., etc.

During the present fiscal year all work has been carried on by hired labor and material procured under existing regulations governing purchases and services, excepting the stone for masonry of Locks Nos. 2 and 5 was obtained under formal written contracts, viz: For Lock No. 2, Petitdidier & Allen, contractors, Nashville, Tenn.; contract dated October 13, 1894; date of beginning work, between March 1 and 10, 1895; date of expiration of contract, October 13, 1896; total consideration, $57,864.50; contract still in force. For Lock No. 5, James H. Connor, contractor, Lebanon, Tenn.; contract dated January 19, 1895; to begin work April 1, 1895; expiration of contract, April 1, 1896; total consideration, $57,724. Mr. Conner failed to carry out his contract and it terminated April 2, 1896, under its terms.

The total amount expended during the fiscal year, not including the expenditures on account of Smith Shoals, was $95,652.09, divided as follows:

Lock No. 1	$130.15
Lock No. 2	67,000.93
Lock No. 3	7,170.14
Lock No. 4	7,862.80
Lock No. 5	1,649.62
Lock No. 6	556.30
Lock No. 7	130.67
Lock No. 21	96.57
Lock No. 22	96.58
Channel work	677.61
Towboat *Weitzel*	3,451.91
Towboat *Susette*	1,518.03
Tender *John Phœnix*	504.93
Derrick boat, new hull, fitting up machinery, etc	1,564.36
Office and contingent expenses	3,241.49
Total	95,652.09

Lock 1 (2.5 miles below Nashville).—Masonry of lock and abutment of dam being completed, no work was done during the fiscal year other than watching and taking care of lock keeper's house and engineer property.

Lock 2 (9 miles above Nashville).—Seven thousand three hundred cubic yards earth, etc., excavated from lock pit; 1,795 cubic yards earth removed from foundation of wing walls; 1,975 cubic yards of material placed behind land wall; 5,070.39 cubic yards of masonry laid in lock walls; 300.66 cubic yards of concrete laid in foundation of lock chamber; 134,059 bricks placed in culverts; 470 cubic yards stone quarried for riprap protection of banks; 500 cubic yards of material excavated; clearing channel to landing pier; moved 30 cubic yards of stone from Dodson quarry (old lock site); resloped banks after slides caused by rapid fall of river at flood stages. Miscellaneous work: Grading and paving right of way to lock site; quarrying and breaking stone for concrete; trimming miter-sill stone; erecting temporary protection over machinery; whitewashing and repairing temporary buildings; fencing United States lands; repairs of boats, stone cars, water tank, etc.

Six thousand three hundred and thirty and forty-one one-hundredths cubic yards of stone—total cost, $39,286.67—for masonry of Lock 2 furnished under contract. The prices per cubic yard delivered on barges are as follows: Hollow quoins, $21; sill, $15.50; special stones and coping, $13.50; pointed face, $10; squared faced rubble, $4.50; backing, $3.

Lock 3 (26 miles above Nashville).—Laying of masonry completed. Masonry pointed, 10.75 linear feet; paving laid behind lock wall, 199 cubic yards; retaining wall built below lock, 89 cubic yards; excavated lower approach, 13 cubic yards rock, 450 cubic yards earth, mud, etc.; concrete laid over upper culverts, 67.5 cubic yards. Miscellaneous: Trimming backing of top course of land wall to make bond with coping; placing stones to mark boundary of United States lands; removing cofferdam, etc. Active operations at Lock 3 suspended August 15, 1895. Engineer property and works in care of watchman.

Lock 4 (44¾ miles above Nashville).—Masonry of lock completed. Miscellaneous work since November: Continued the removal of cofferdam, also drift from head of lock walls; cleared bank of logs and drift above and below lock, and graded same for sodding or riprapping with stone; moved spalls from quarry to bank for riprapping; built new hull for steam derrick boat, as authorized; made repairs of dredge and barges, etc.

Lock 5 (72 miles above Nashville).—Received 880.14 cubic yards of stone for masonry of lock walls under contract, contract prices for the classes furnished being as follows: Pointed face, $9; squared faced rubble, $4.50; backing, $3.50. Total stone received under this contract only 1,550.63 cubic yards, out of 11,061 cubic yards contracted for. Contract terminated April 2, 1896, under its terms.

Lock 6 (89.5 miles above Nashville).—Sites for lock and abutment acquired by the United States.

Locks 7, 8, 21, 22 (107, 125¼, 296¼, and 320¼ miles above Nashville, respectively).—The sites of Locks 21 and 22 are in Kentucky, 28¾ and 4¾ miles below Burnside. The sites for these locks and abutments have been approved and purchase authorized at reasonable prices; condemnation proceedings have been instituted to acquire sites of Locks 7, 21, and 22; the site for abutment of Dam No. 7 has been purchased and title approved; conveyance will be made as soon as practicable. Purchase has been made of the site for abutment No. 22, subject to the opinion of the Attorney-General of the United States as to title.

The lands acquired and to be acquired by the United States for sites of locks and dams under the existing project, so far as determined, distance above Nashville, acreage, cost, including abstracts of title, registration fees, etc., are as follows:

No. 1. 2¼ miles below Nashvile, 7.8 acres, cost	$1,371.60
No. 2. Old site; 10½ miles above Nashville, 12½ acres, cost	750.43
No. 2. New site; 9 miles above Nashville, 12.05 acres, cost	1,728.80
No. 3. 26 miles above Nashville, 15.2 acres, cost	2,578.93
No. 4. 44¾ miles above Nashville, 14.8 acres, cost	2,576.21
No. 5. 72 miles above Nashville, 18.5 acres, cost	1,696.40
No. 6. 89½ miles above Nashville, 12.85 acres, cost	1,199.65
No. 7. 107 miles above Nashville, 14.88 acres, not yet acquired.	
No. 8. 125¼ miles above Nashville, 16.23 acres, not yet acquired.	
No. 21. 296¼ miles above Nashville, 17.44 acres, not yet acquired.	
No. 22. 320¼ miles above Nashville, 17.92 acres, not yet acquired.	

The U. S. towboat *Weitzel* has been actively employed during the fiscal year in towing stone to Lock No. 2 and moving the heavy supplies incident to the work of construction at the several locks. In June it was docked at Paducah, Ky., and hull thoroughly repaired.

The tender *John Phœnix*, being of light draft, has rendered good service while making the surveys for lock sites and in general service required by the work in progress, and by assisting in snagging operations necessary to the maintenance of the improved channel.

The U. S. towboat *Susette* has been employed in the general towing necessary between Nashville and the various locks, and in moving stone barges from quarry to Lock 2.

Channel work.—A snagging party, with steam derrick boat and the U. S. tender *John Phœnix*, moved from Nashville to Burnside, Ky., in May; reached Burnside June 6. After making necessary repairs to the machinery of the *John Phœnix*, the party left Burnside on June 15 and reached Cloyds Landing, about 105 miles, at the close of the fiscal year, clearing the channel of surface obstructions en route. The following was the work done on this reach of the river: Three hundred and forty-five snags and logs and 3 bowlders removed from channel and 276 leaning trees cut down.

By act of June 3, 1896, $20,000 was appropriated for purchasing sites for Locks and Dams Nos. 21 and 22, and in laying masonry for the same. In the interest of the improvement generally it is preferable that the masonry of Lock No. 21 be first pressed to completion, therefore the amount available after paying for the sites can be best applied at Lock 21 in clearing site, construction of cofferdam, preparing foundation for lock walls, and in the contingent expenses incident to the work.

The same act also provides for the completion of the whole or any part of locks numbered 5, 6, and 7, under the continuous contract system, or otherwise than by contract, not to exceed in the aggregate $600,000, subject to the limitations as to payments enacted in section 5 of said act. Project for the expenditure of the $600,000 has been submitted for approval.

Several slides in the banks, caused by the rapid fall of the river from high-flood stages, occurred at various points in the upper Cumberland similar in character and cause to the slides mentioned as occurring "below Nashville."

Smith Shoals, Kentucky.—From 1876 to 1882 the sum of $115,000 was appropriated for this section (see list of appropriations, ante), which under the old project has been expended in open channel work by hired labor. Operations were suspended in May, 1884.

The improvement of these shoals by locks and dams forms a part of

the existing project for the canalization of the river above Nashville; the Smith Shoals system consisting of seven locks and dams between Burnside, Ky., and mouth of Rock Castle River. (Report Chief of Engineers, 1891, p. 2270.) It has been ascertained that the seven locks will not be necessary owing to an increase of lift in the other locks, which is rendered advisable by reason of the small river discharge at low water not permitting of any material loss during the season of navigation; also, simplicity of operation and maintenance at the rather inaccessible locations necessarily selected for the lock sites. The project has therefore been modified, reducing the number of locks to six; modification approved August 12, 1895.

Allotments made from appropriations for improving Cumberland River above Nashville, Tenn., for this section are as follows:

Amount allotted "at Smith Shoals," act of September 19, 1890	$50,000.00
Amount allotted "above Burnside," act of July 13, 1892	5,000.00
Amount allotted "above Burnside," act of August 17, 1894	5,000.00
Total allotted	60,000.00
Amount expended to June 30, 1896	18,506.76
Balance available July 1, 1896	41,493.24

The allotments by act of July 13, 1892, and August 17, 1894, provided that $5,000 of each of said general appropriations may be used in the improvement of the river above the town of Burnside. It was recommended and approved that these sums be applied to the Smith Shoals system of lockage, as projected "above Burnside."

The amount expended on this section to June 30, 1895, was $15,743.58, which was applied to the survey of the river from Burnside or the junction of the South Fork to the mouth of Rock Castle River, about 30 miles, and having a fall of 77 feet in that distance. An extensive system of test borings and soundings was necessary in order to determine the location of the sites most suitable. The sites for Locks and Dams Nos. 1 to 6, inclusive, have been selected. Survey of mouth of "Suck," and line of levels run into the cave at Cave Creek.

During the present fiscal year (July) the maps of the proposed sites were completed and with report forwarded to the Chief of Engineers. The sites 1 to 6 were approved and authority granted to obtain the lands by purchase or condemnation, if necessary. No site has yet been conveyed to the United States.

Amount expended in fiscal year, $2,763.18.

The field and office work pertaining to the surveys of the sites for the locks and dams forming part of the project for canalization of the Cumberland River from the mouth of Harpeth River on the Cumberland River, below Nashville, to the head of Smith Shoals, mouth of Rock Castle River, including the work of lock construction in progress, has been and now is under the efficient immediate management of Mr. J. S. Walker, principal assistant engineer.

The amount hereinbelow estimated for continuing the work, $1,000,000, can be profitably expended in building abutments at Dams 2, 3, and 4, constructing dams, lock gates, and maneuvering appliances, etc., complete at Locks 1 to 7, inclusive, excavating approaches to said locks, where necessary, so as to open the same to navigation, and canalizing the river to a point about 107 miles above Nashville, Tenn. About $5,000 of the amount estimated for should be held available for expenditure in open channel work, snagging, etc., between Burnside

and Nashville, so as to maintain the channel in good navigable condition during the progress of lock construction.

Estimate for improving Cumberland River by locks and dams from Nashville to head of Smith Shoals, as modified in 1891	$7,500,000.00
Amount appropriated	995,000.00
Amount expended, including outstanding indebtedness and covered by uncompleted contracts	867,534.60

Upon a revision of the estimate of cost of improving the Cumberland River above Nashville, it is found necessary that the estimate for the canalization of the upper Cumberland be increased to $9,000,000, which increase has been approved. Therefore in the money statement herewith it is reported that the amount required for completion of existing project is $7,505,000 in lieu of $6,505,000, as originally estimated. The reason for this increase is that though the original estimate of cost of each of the thirty locks, more or less, of the series, would be sufficient if the work could be carried on regularly and rapidly, yet it will not be sufficient under the limited appropriations made and the methods now obligatory. At the present rate of progress it will take from seventy-five to one hundred years to complete the improvement projected. The deterioration of value of plant and other heavy expenses incident to frequent and sometimes long-continued delays, and the inability to prosecute the work vigorously by reason of lack of funds, all tend to increase the cost and render progress unsatisfactory.

The periodic work for maintenance, including the necessary annual snagging operations, in addition to the original work of lock construction, in its present condition, is estimated to cost about $5,000 per year; as each lock is completed, the increased cost of maintenance will be from $4,000 to $6,000 per lock; therefore when the system of lockage—about 30 locks—is completed, the cost of maintenance will reach about $150,000 per annum.

Money statement.

July 1, 1895, balance unexpended		$220,088.53
Amount appropriated by act of June 3, 1896		20,000.00
		240,088.53
June 30, 1896, amount expended during fiscal year		98,415.27
July 1, 1896, balance unexpended		141,673.26
July 1, 1896, outstanding liabilities	$3,197.60	
July 1, 1896, amount covered by uncompleted contracts	11,010.26	
		14,207.86
July 1, 1896, balance available		127,465.49
Amount (estimated) required for completion of existing project		7,505,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898		1,000,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		

REPORT OF BOARD OF ENGINEERS RELATIVE TO MODIFICATION OF PROJECT FOR CONSTRUCTION OF LOCK NO. 5, CUMBERLAND RIVER, TENNESSEE.

UNITED STATES ENGINEER OFFICE,
Nashville, Tenn., August 26, 1896.

GENERAL: The Board of Engineers constituted by Special Orders No. 21, Headquarters Corps of Engineers, August 3, 1896, met at Nashville on the morning of August 26, 1896.

The Board had before it the papers mentioned in your letter of August 6, 1896, all of which were carefully considered; the Board also proceeded to the site of Lock No. 5, Cumberland River, and inspected the same. After going fully into the merits of each case the Board came unanimously to the following conclusions:

1. * * * That the present excavation for a concrete floor 8 feet thick be filled up for a depth of 5 feet with broken stone, and with gravel if necessary, and that a concrete floor 3 feet thick be laid on the foundation of loose material thus prepared; that through the unexcavated portion of the foundation of the floor such drains be laid as will carry off all water leaking in through the bottom, care being taken to give such directions to the drains as will prevent water coming in from outside whenever the lock shall be pumped out; that a cross wall of concrete be built at least 6 feet downward, from the underside of the concrete floor of the lock, under the head bay, and a similar wall under the tail bay; and that the foundations of the side walls of the lock be at the same depth as the bottoms of the cross walls.

2. In the case of Lock No. 5, Cumberland River, it is recommended that a similar construction be adopted, such variations to be made as the difference in site requires, the concrete floor being limited in thickness to 3 feet.

While the Board does not consider the holding-down bolts recommended by Captain Biddle as essential, it recommends, on account of the lightness of the cost of putting them in, that discretion as to their use be left with Captain Biddle, the bolts to be applied or not according as their use is shown to be advisable or not during the progress of construction.

Respectfully submitted.

F. A. MAHAN,
Major, Engineers.
W. L. MARSHALL,
Major, Corps of Engineers.
JOHN BIDDLE,
Captain, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

COMMERCIAL STATISTICS.

Cumberland River below Nashville, Tenn., from July 1, 1895, to June 30, 1896.

Articles.	Tons.	Articles.	Tons.
Bricks	145	Lumber	2,100
Cattle	760	Salt	1,140
Coal	380	Sand	5,391
Cotton	40	Shingles	60
Flour	450	Staves	2,100
Grain	5,110	Tobacco	5,200
Hay	280	General merchandise	13,500
Horses and mules	480		
Hogs	640	Total tonnage	40,676
Iron	2,900		

Estimated value, $1,978,533.
Number of passengers carried, 8,150.

Cumberland River above Nashville, Tenn., from July 1, 1895, to June 30, 1896.

Articles.	Tons.	Articles.	Tons.
Bricks	484	Lumber	3,928
Cattle	856	Salt	1,366
Coal	1,870	Sand	10,782
Cross-ties	136	Shingles	100
Flour	861	Staves	910
Grain	4,702	Stone	663
Hay	90	Tobacco	2,390
Horses and mules	260	General merchandise	17,380
Hogs	1,395		
Iron	220	Total tonnage	48,393

Estimated value, $2,574,413.
Number of passengers carried, 7,889.

Cumberland River above Nashville, Tenn., above Burnside, Smith Shoals, from July 1, 1895, to June 30, 1896.

Articles.	Tons.
Coal	700
Cross-ties	12,000
Grain	3
Logs	11,400
Staves	118
Total tonnage	24,221

Estimated value not reported.

List of steamboats (stern-wheel) plying on the Cumberland River, Tennessee and Kentucky.

Name.	Length.	Breadth.	Depth.	Tonnage.
	Feet.	*Feet.*	*Feet.*	
Ashland City	120	20	3.9	94.55
A. L. Goldberg	129	20	3	58.20
Clayton H. Webb	112.5	24.7	3	98.75
Jas. N. White	147	27	3	77.19
John Orm No. 3	95	17	3.5	95.33
John W. Hart	168	29	3	215.97
R. Dunbar	160	29.4	6.4	158.80
Sycamore	103.6	20.3	3	69
W. K. Phillips	165	30	4	195.06
W. T. Harwell	72.9	15.9	3.8	24.48
Will J. Cummins	160	30	4.1	177.25
Alex. Perry	149.9	28.5	3.5	172.76
Wash. Honshell	157	28.6	4	134.99
Fritz	120	26	3.8	153.12
Lula E. Warren	122.5	22.5	3.3	90.58
Maggie Belle	95.6	18.4	3.6	52.81
New Crescent	111	18	2.8	88.88
S. H. Paul	80	16	3.4	68
Burnside	136	22	4.1	192.11

NOTE.—Two of the steamboats, *New Crescent* and *S. H. Paul*, were sunk during the fiscal year by striking hidden obstructions between Burnside and Butlers Landing. The *New Crescent* proved to be a total loss. The *S. H. Paul* was raised and repaired.

APPENDIX B B.

IMPROVEMENT OF TENNESSEE RIVER AND ITS TRIBUTARIES.

REPORT OF CAPT. DAN C. KINGMAN, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1896, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

IMPROVEMENTS.

1. Tennessee River.
2. Operating and care of Muscle Shoals Canal, Tennessee River.
3. Hiwassee River, Tennessee.
4. French Broad and Little Pigeon rivers, Tennessee.
5. Clinch River, Tennessee.

ENGINEER OFFICE, UNITED STATES ARMY,
Chattanooga, Tenn., July 18, 1896.

GENERAL: I have the honor to transmit herewith * * * my annual report for the works of river and harbor improvement in my charge for the fiscal year ending June 30, 1896.

Very respectfully, your obedient servant,

DAN C. KINGMAN,
Captain, Corps of Engineers.

Brig. Gen. W. P. CRAIGHILL,
Chief of Engineers, U. S. A.

THE DISTRICT.

From the beginning of the fiscal year to July 11, 1895, the works of improvement on the various rivers in this district were under the charge of Capt. Theo. A. Bingham, Corps of Engineers; from July 11, 1895, to November 21, 1895, under the charge of Lieut. James F. McIndoe, Corps of Engineers; and from November 21, 1895, to the close of the fiscal year, under the charge of Capt. Dan C. Kingman, Corps of Engineers. Except for the peried July 11, 1895, to November 21, 1895, Lieutenant McIndoe has been assistant to the engineer officer in charge.

The Division Engineers were Col. Henry M. Robert, Corps of Engineers, at New York until December 14, 1895; and Col. John W. Barlow, Corps of Engineers, at Washington, D. C., from February 5, 1896.

The historical parts of this report have been adopted from former annual reports of the engineer officers in charge of works of improvement of the different rivers now comprising this district.

PRECISE LEVELS.

In the spring of 1895 Capt. Theo. A. Bingham, Corps of Engineers, obtained authority from the Chief of Engineers to have lines of precise levels run from Corinth, Miss., to points on the Tennessee River, and to use for this purpose the unexpended balances of the two allotments for general improvement of the river, amounting to $3,554.32.

The party was organized and took the field under Assistant Engineer O. W. Ferguson April 20, 1895, and by the end of fiscal year June 30, 1895, had reached Decatur, Ala.

The United States Coast and Geodetic Survey on their line from Mobile, Ala., to Odin, Ill., established two permanent bench marks in Corinth, Miss., in 1889. In 1890–91 they ran a line of precise levels from these two bench marks "V" and "W" to Memphis, Tenn., where connection was made with "U. S. P. B. M. Memphis," established by the Mississippi River Commission.

The bench marks in Corinth were, therefore, quite accurately determined and made a convenient starting point for connecting with the Tennessee River. Our party followed the line of the Memphis and Charleston Railroad from Corinth, Miss., to Riverton Junction, Ala. (30 miles); thence along the Birmingham, Sheffield and Tennessee River Railroad to Riverton, Ala. (11 miles); thence along the river bank, past the site of the lower lock of Colbert Shoals Canal, to the stone post marking the south corner of United States land (2 miles). The party then returned to Riverton Junction and ran a line along the railroad to Florence, Ala. (28 miles), running also a side line from Prides Station to the river (1 mile). At Florence the line crossed over the railroad bridge to the north side of river, whence it proceeded to and along the line of the United States Muscle Shoals Canal to a point 1 mile above Nance Reef, where it again crossed the river and from this point followed the south bank to Decatur, Ala. (51 miles), taking in the upper division of Muscle Shoals Canal.

The party returned to Riverton and ran a line from there along the left bank of the river to a point 4 miles below Pittsburg Landing, Tenn. (33 miles), where, on account of lack of funds, the field work was brought to a close. The point of closing was carefully marked by four bench marks, so that if ever in the future it is desired to continue this work a point of beginning will be easily found.

The party was disbanded at Riverton, Ala., July 31, 1895. Mr. O. W. Ferguson and one recorder were retained to compute the results.

The line of precise levels covered a distance of 165 miles, 72 of which were along the railroad and 93 along the river bank. The original allotment was not sufficient to complete the computation of the results, and therefore authority was obtained to continue the work in order to put it in such shape that its value could be realized. The total cost of the field work for the 165 miles was $3,525.18 and for office work $1,196.62, or a final cost of $28.62 per mile.

The rods and instruments used were kindly lent by the secretary of the Mississippi River Commission. For details of instruments, methods of work, location, and description of bench marks, and tabulation of results, see appended report (Appendix B) of Assistant Engineer O. W. Ferguson.

MAPS AND DATA.

During the year work was continued on piecing together such surveys as exist with a view to locating the future surveys needed to complete a continuous map and profile of the Tennessee River. It was

very desirable that the maps of these detached surveys be plotted to the same scale on uniform sheets and that the channel profile be clearly indicated. The scales adopted were, for the maps, 1,000′=1″; for the profile (horizontal), 2,000′=1″, (vertical) 20′=1″. Size of sheets is 24 by 36 inches inside border. The reach from South Chickamauga Creek to the lower end of Bridgeport Island, a distance of 56.8 miles, is comprised on six sheets. The original is on one sheet of mounted paper. The reach from Bridgeport Island to Browns Ferry, a distance of 105 miles, has never been surveyed by United States engineers. It is proposed for the present to supply this deficiency by means of a reconnoissance based on the land-survey maps.

The reach between Browns Ferry and Florence, a distance of 37.8 miles, which includes the line of United States Muscle Shoals Canal, is comprised on six sheets. The original is on one sheet of mounted paper.

The reach between Florence and Riverton, a distance of 30 miles, which includes the line of proposed United States Colbert Shoals Canal, is comprised on five sheets. The original between Florence and Colbert Shoals is on one sheet of manila paper, and from Colbert Shoals to Riverton on one sheet of mounted paper.

All survey books, survey notes, and sketches of the district have been marked, indexed, filed, and made quickly available for use.

GAUGES AND DISCHARGE RECORDS.

Gauge records have been carefully gone over, gaps filled as far as was found possible, and the records marked, indexed, and plotted on proper hydrograph sheets.

There is presented in the following table all available data concerning the various gauges on the Tennessee River and tributaries where readings have been taken:

Gauge data, Tennessee River and tributaries.

[This table has been prepared from the latest and most authentic information to be found in this office or in the published records of the Weather Bureau. The elevations between Knoxville and Bridgeport are from the surveys of 1891; between Decatur and Riverton, from the precise levels of 1895, and the remaining elevations are mainly from railroad levels.]

Location.	River.	Read by—	Distance from Paducah.	Elevation above sea level.									Drainage area above gauge.
				Zero of gauge.	Low water.			High water.			Danger line.		
					Gauge.	Elevation.	Date.	Gauge.	Elevation.	Date.	Gauge.	Elevation.	
			Miles.										*Sq. Miles.*
Bluff City	Holston	Weather Bureau	780.0										
Strawberry Plains	do	do	660.0	859.79	—1.5	858.29	Dec. 8, 1895	52.0	911.79	Mar. 7, 1867	26.0	885.79	6,400
Leadvale	French Broad	do	700.0	951.92	—0.5	950.42					14.0	965.92	
Knoxville	Tennessee	Weather Bureau and U. S. Engineers.	635.2	806.60	—1.0	805.60	Dec., 1895	43.2	849.80	Feb. 26, 1875			
Do	do	do						45.1	851.70	Mar. 9, 1867	29.0	835.60	11,700
Loudon	do	do	578.8	737.10	—1.0	736.10	Dec., 1895	40.0	777.10	Feb. 26, 1875			
Do	do	do						43.1	780.20	1867	25.0	762.10	14,800
Spears Ferry	Clinch	Weather Bureau	710.0			1,306.00			1,324.00				
Clinton	do	do	596.0	782.30	+0.3	782.60		45 0	827.30	Mar. 31, 1886	25.0	807.30	3,300
Kingston	do	do	556.2	712.80	—0.9	711.90	Dec., 1894	39.7	752.50	Feb. 26, 1875			
Do	Tennessee	do						42.4	755.20	1867	25.0	737.80	19,500
Rockwood	do	do	540.5	699.70	—0.8	698.90	Dec., 1894	41.5	741.20	Feb., 1875			
Do	do	do						44.5	744.20	1867	20.0	719.70	
Charleston	Hiawassee	do	508.0	684.00	—0.1	683.90	Dec, 1894	32.2		Mar., 1886			2,300
Chattanooga	Tennessee	Weather Bureau and U. S. Engineers.	451.6	630.64	0.0	630.64	Sept., 1881	53.96	684.58	Mar., 1875			
Do	do	do							688.64	1867	33.0	663.64	24,400
Chattanooga Creek	do	U. S. Engineers	448.4			626.00	Sept., 1881		688.46	Mar., 1875			
Do	do	do							685.70	1867			
Tumbling Shoals	do	do	442.4	618.00	0.0	618.00	Sept., 1881		679.70	Mar., 1875			
Do	do	do							683.20	1867			
Poorhorse Bar	do	do	442.3	613.61		613.61	Sept., 1881		678.90	Mar., 1875			
The Suck	do	do	440.3	612.78		612.78	do		680.85	1867			
Do	do	do							675.54	Mar., 1875			
The Skillet	do	do	436.3			606±	Sept., 1881		664.51	1867			
Do	do	do							659.80	Mar., 1875			
Shellmound	do	do	411.7	597.92					638.51	do			
Bridgeport	do	do	402.0	593.58	—0.36	593.22			632.82	1867			
Do	do	do							630.75	Mar., 1875			
Guntersville	do	do	347.0		0.0			46.16		1867			
Do	do	do						44.34		Mar., 1875			

Decatur	do	Weather Bureau and U. S. Engineers.	302.5	530.00	—0.8	529.20	Oct., 1884	28.5	558.50	1867			
Do	do	do						27.6	557.60	1875	21.0	551.00	29,900
Miltons Bluff	do	U. S. Engineers	285.3	522.95	0.0	522.95	Oct., 1891	9.5	531.45	Jan. 23, 1882			
Do	do	do							533.45	1867			
Lock A	Elk River Creek	do	284.1	520.88	+5.2	526.08	Nov., 1894	12.8	533.68	Apr. 13, 1892			
Lock B	do	do	282.8	506.58	+2.4	508.98	Nov., 1895		528.30	1867			
Do	do	do							525.40	1882			
Do	do	do							522.98	Apr. 11, 1892			
Lock No. 1	Muscle Shoals Creek	do	274.9	499.32	+3.5	502.82	Nov., 1894		514.20	1882			
Do	do	do						13.6	512.92	Apr. 9, 1892			
Lock No. 9	do	do	261.0	418.48	—0.8	417.68	Dec., 1895		436.25	1867			
Do	do	do						12.8	431.28	Apr. 8, 1892			
Little Muscle Shoals	Tennessee	do	259.0	418.45	—0.15	318.30	Sept., 1879	11.3	429.75	Mar. 17, 1880			
Florence	do	Weather Bureau and U. S. Engineers.	254.6	396.77	—0.76	396.01	Sept., 1878	31.08	427.85	1867			
Do	do	do						29.40	426.17	Mar. 8, 1875			
Do	do	do						29.60	426.37	Jan. 22, 1882	30.0	426.77	23,900
Colbert Shoals	do	U. S. Engineers	233.1	383.57	+0.1	383.67	Nov., 1894		411.86	1882 and 1867			
Do	do	do						20.0	403.57	Apr. 9, 1892			
Gauge No. 2 (Colbert Shoals)	do	do	228.6	370.10	—1.2	368.90	Nov., 1891	23±	402.10±	do			
Gauge No. 3 (Colbert Shoals)	do	do	226.8	365.86	—0.65	365.21	do		408.36	1882 and 1867			
Do	do	do						32.00	397.86	Apr. 9, 1892			
Riverton	do	do	224.8	359.86	—1.6	358.26	Nov., 1894 and 1895.		407.66	1882 and 1867			
Do	do	do						39.8	399.66	Apr. 9, 1892			
Columbia	Duck	Weather Bureau	170.0	519.40	—0.4	519.00		33.0	552.40	Mar. 8, 1891	28.0		1,300
Johnsonville	Tennessee	do	95.0	315.55	—0.1	315.45	Sept., 1884		360.79	1867			
Do	do	do							361.06	Mar., 1875			
Do	do	do							362.95	Jan., 1882	21.0	326 55	41,600
Paducah	Ohio	do	00.0	287.16	—0.7	286.46	Nov., 1894	54.25	341.41	Feb. 23, 1884	40.0	327.16	201,200

Gauge readings have been taken continuously during the year at head and at foot of Colbert Shoals. at Florence, at the pier and Locks A, B, 1, and 9 of Muscle Shoals Canal, at Decatur, at Bridgeport, and to August 11, 1895, at Kingston on Clinch River.

In addition the Signal Service has furnished this office with continuous records for the year, of their gauges at Paducah, Ky., and at Chattanooga, Tenn.

All records of discharge measurements on the Tennessee River and tributaries have been carefully studied by Asst. Engineer George T. Nelles. For the results of his study, see his appended report (Appendix C).

BRIDGES.

A general bridge law is much needed for the Tennessee River, clearly defining what facilities for the passage of boats must be complied with by companies owning or operating bridges over this river, and establishing penalties for violation.

It seems pertinent to quote the following from the annual report of Colonel Barlow for 1890:

> The number of bridges now spanning the Tennessee River, when taken in connection with the number proposed to be constructed under the recent enabling acts of Congress, forms a very important matter for consideration where the interests of navigation are concerned.
>
> All bridges are obstructions in a greater or less degree, and it is highly desirable that all new bridges be constructed with a view to securing those having continuous spans a certain width and height above high water in their navigation spans, and in drawbridges a certain uniform width of clear waterway in their drawspans.

The following tables show existing bridges and those authorized to be built by Congressional sanction over the Tennessee River:

Existing bridges (12).

Location.	Operated by—
Knoxville, Tenn	Marietta and North Georgia R. R.
Do	County.
Do	East Tennessee, Virginia and Georgia R. R. (Southern).
Loudon, Tenn	Do.
Chattanooga, Tenn	Cincinnati Southern R. R. (Q. & C.).
Do	Chattanooga Bridge Co.
Bridgeport, Ala	Nashville, Chattanooga and St. Louis R. R.
Decatur, Ala	Memphis and Charleston R. R.
Florence, Ala	Do.
Johnsonville, Tenn	Nashville, Chattanooga and St. Louis R. R.
Danville, Tenn	Louisville and Nashville R. R.
Gilbertsville, Ky	Chesapeake, Ohio and Southwestern R. R.

New bridges authorized (13).

Location.	To be built by—	Date of act.
Kingston, Tenn., within 15 miles of junction with Clinch.	Fairmount Valley R. R	Aug. 7, 1894
Chattanooga, Tenn	Chattanooga Western R. R. Co	Jan. 27, 1894
Guntersville, Ala	Huntsville and Birmingham R. R. Co	Mar. 3, 1887
Deposit, Ala	Gurleys and Paint Rock Valley R. R. Co	July 30, 1892
Whitesburg precinct, Ala	Huntsville Bridge Co	July 27, 1892
Between Colbert and Lauderdale counties, Ala.	Mexican Gulf, Pacific and Puget Sound R. R. Co.	June 21, 1892
Foot of Muscle Shoals Canal, Alabama.	Tennessee Bridge Co	Mar. 3, 1887
Sheffield, Ala	Sheffield Land, Iron and Coal Co	Do.
Do	Tennessee Bridge and Ferry Co	Mar. 3, 1893
Do	do	Mar. 2, 1895
Clifton, Tenn	St. Louis and Birmingham R. R. Co	Apr. 21, 1894
Counties Perry and Decatur, Tenn	Nashville, Jackson and Memphis R. R. Co	May 17, 1886
Birmingham, Ky	Cairo and Tennessee River R. R. Co	Sept. 25, 1892

During the fiscal year 1895–96 bills were introduced in Congress for the construction of two additional new bridges over the Tennessee River, one at Knoxville, Tenn., and one at New Decatur, Ala., and the plans were referred to this office for report. The site of the Knoxville Bridge has been examined, the final plans approved, and the authorizing act passed by Congress.

Authority has also been given for a bridge over the Clinch River in Roane County, Tenn., and for one over the Duck River at Cold Branch Ferry, Tennessee. The latter bridge was reported to the Chief of Engineers as practically completed in accordance with the approved plans by letter dated January 22, 1896.

In February, 1896, a complaint, signed by steamboat owners, masters, pilots, and business men interested in the navigation of the Tennessee River, was filed with the Secretary of War citing the dangers to navigation on account of the bridges across the river at Danville, Tenn., and Gilbertsville, Ky., and asking that the danger be obviated by having the railroad companies construct sheer booms at these places. The complaint was referred to me for investigation and report, and the report was submitted to the Chief of Engineers under date of April 28, 1896.

In accordance with law a public hearing was held in this office on June 18 to enable all parties interested to state their cases. Owing to the peculiar conditions connected with the receivership and prospective sale of the road operating one of the bridges, and in order that all parties interested might have a full opportunity to be heard, the further hearing was postponed until August 18, 1896, when it is to be resumed at the same place.

B B 1.

IMPROVEMENT OF TENNESSEE RIVER.

[Length, 640 miles.]

The junction of the Holston and French Broad rivers, 4½ miles above Knoxville, is now generally taken as the head of the Tennessee River, and in the river and harbor act of 1890 this point appears to have been definitely fixed by the specific language of the act providing for a survey of the Tennessee River from Chattanooga to the junction of Holston and French Broad rivers.

As one of the largest of the fifty-three or more tributaries of the Mississippi River the Tennessee has always held an important place in the projects for the improvement of the navigable waterways of the country. The Muscle Shoals Canal having been opened to navigation, the Tennessee River is now navigable from its source to its mouth, a distance of 640 miles, during several months of the year, and as work is continued upon certain other less formidable obstructions the season of navigation will be correspondingly lengthened. The radical improvement of this river so as to make navigation continuous throughout its entire length for boats of moderate draft is by no means an impossibility.

Now that the great obstruction of the Muscle Shoals has been overcome by the completed canal, and Colbert Shoals is in process of being done away with in the same manner, it is more annoying to the now really brightening prospects for river navigation to have to contend

with the smaller obstructions which exist in a number of places along the river. These obstructions are very short in length, but no whit less obstructive than the longer ones.

1. ABOVE CHATTANOOGA (188 MILES).

This section of the river is navigable during medium and high stages, which usually prevail through the winter and spring months, and occasionally at other seasons during the occurrence of so-called rain tides.

The navigation consists of steamboats carrying freight and passengers, flatboats bringing products from the upper tributaries, and rafts of logs and lumber, also brought from the tributaries, the latter constituting the major part of the commerce of the upper Tennessee River.

In 1830 Col. S. H. Long, United States Topographical Engineers, made a careful examination of the Holston and Tennessee rivers between Kingsport, Tenn., and the Alabama State line. His report, published as House Ex. Doc. No. 167, Forty-third Congress, second session, gives a detailed description of every obstruction to navigation at that time, and plans and estimates for their improvement. In 1871 an examination was made between Knoxville and Chattanooga under the direction of Maj. Walter McFarland, Corps of Engineers. (See Reports of Chief of Engineers, 1871, pp. 502–507, and 1872, pp. 488–494.) The obstructions to navigation, as described in these reports, were "low-water obstructions," consisting of bars, either rock or gravel, extending across the river, with lengths varying from 60 feet to 2 miles, the depth of water over these bars varying from 10 to 30 inches at extreme low water, and the current varying from 2½ to 6 miles per hour.

The bed and banks of the river are of such character as to make any improvements more or less permanent, with the exception of the removal from time to time of such drift or snags as may be brought down by the annual floods.

In 1832 the State of Tennessee undertook the improvement of certain points above Chattanooga by removal of rock and construction of wing dams, but there is no record of the work done, and it did not prove of lasting value.

In 1871 an examination was made and upon it a project of improvement based which provided for the removal of snags and drift and for deepening the channel at the worst obstructions by blasting and dredging, or by scouring the bars by the aid of wing dams, to an extent that will secure a channel 3 feet in depth at average low water, and at an estimated cost of $340,000. The estimate of 1871 was increased in 1874, 1877, 1884, and 1891, for the reasons stated in the reports of those years.

Under the provisions of the river and harbor act of September 19, 1890, a "careful and comprehensive survey" of the Tennessee River above Chattanooga was made, "with a view of ascertaining to what extent the navigation of the river is capable of improvement, and the cost of the same, and the preparation of suitable plans therefor." This survey was begun in May, 1891, and completed during the fiscal year year 1893. The report, with estimate and plans, was submitted to the Secretary of War in February, 1893, and forms House Ex. Doc. No. 252, Fifty-second Congress, second session. The plan of improvement proposed was the same as that formerly in progress, as above stated; that is, to obtain a 3-foot low-water navigable channel between Chattanooga and the mouth of the French Broad River, at an additional estimated cost of $650,000. The project based on the survey of 1891

received Congressional approval in the river and harbor bill of August 17, 1894.

Eighteen appropriations have been made by Congress for this work, aggregating the sum of $361,000, viz:

Act of—		Act of—	
April 10, 1869	$35,000	August 2, 1882	$7,000
June 10, 1872	25,000	July 5, 1884	3,000
March 3, 1873	25,000	August 5, 1886	7,500
June 23, 1874	25,000	August 11, 1888	15,000
March 3, 1875	40,000	September 19, 1890	30,000
August 14, 1876	15,000	July 13, 1892	25,000
June 18, 1878	15,000	August 17, 1894	50,000
March 3, 1879	11,500	June 3, 1896	15,000
June 14, 1880	10,000		
March 3, 1881	7,000	Total	361,000

The amount expended, including outstanding indebtedness, to June 30, 1895, was $305,606.86. This expenditure has resulted in giving a lengthened season of navigation and an improved channel at 29 of the 43 obstructions enumerated by Colonel Long in his report of an examination made in 1830. Operations have consisted generally of excavating rock and gravel from the channel and building stone dams where necessary to give increased depths over reefs and shoals. The work done at White Creek Shoals, which was formerly considered the head of navigation at medium stages, has been particularly successful. By extending the main dam and adding two spur dams there is now not less than 3 feet in the channel at low water where formerly there was less than 1 foot. The dams are so located that as the water falls after a rise the bar, which invariably forms during high water, is scoured out. This one improvement has lengthened several months the boating season to Kingston. At Soddy Shoals the raising and tightening of the dams and blasting out of the reefs have resulted in a channel of not less than 3 feet at low water where but a few years ago there was less than 1½ feet. Before the improvement this shoal was very dangerous, and several steamboats and barges were sunk there. Since the improvement there have been no complaints. At Caney Creek Shoals to the close of the fiscal year June 30, 1895, the work was mainly channel excavation, with a small amount of dam building. The excavated channel was marked by 30 buoys and 2 beacons, and the work accomplished has given satisfaction to pilots, preventing a serious accident in one case to the steamer *Wyeth City* and tow during a heavy fog. Work was resumed at Caney Creek Shoals July 30, 1895. The whole force worked at the quarry getting out stone for dams and at repairs to the incline leading from the quarry to the river until August 19, when channel excavation was resumed. A drilling raft, designed by Supt. R. R. Thacher, was used for supporting the Rand steam drills. It proved to be a very valuable addition to the plant, and resulted in a saving of 60 per cent in cost of drilling as formerly done. The details of this raft are shown in the accompanying drawing.

The channel at Caney Creek Shoals crosses from the right bank to the left bank of the river. The old crossing, beginning at a point 1,100 feet below Caney Creek, was very crooked, and boats had great difficulty in following it, especially at night or in a wind. A new crossing, straight and with a clear width of 200 feet, was located 1,600 feet below the old one, and at the close of the working season was nine-tenths completed. The channel in the crossing will have a depth of not less than 3 feet, and will be marked by buoys. Posts, with diamond-shaped targets, will also be erected on the bank for the guidance of the pilots.

One thousand two hundred and ninety-nine cubic yards of solid rock and 63 cubic yards of loose rock were excavated from the channel. It was used in extending dams and in riprapping the right bank from the mouth of Caney Creek to the new crossing.

November 14, 1895, the water, having reached a temperature of 52°, became too cold for the men to work in it, and channel work was discontinued.

At the head of the shoals, an old State dam, by deflecting the current into the right bank, had caused considerable cutting and caving. To prevent further caving and to assist in removing a bar, which the material from the bank was forming just below, a crib 300 feet long, of 6 by 12 inches by 20 to 35 feet white-oak timber, was built and tied to the bank with logs. The crib was filled with stone boated from the quarry.

The lower dam had been extended 872 feet when work was suspended for the season, December 2, 1895. The fleet was towed to Kingston and placed in winter quarters.

During the winter the boats were overhauled, one new quarter boat and one new hull built. The cabin of an old boat was transferred to the new hull and the cabin extended.

April 29, 1896, the fleet returned to Caney Creek Shoals and work at the quarry was resumed. Two new derrick barges have been built for use as soon as the river gets low enough for channel work.

Work done and cost of same at Caney Creek Shoals, upper Tennessee River, during fiscal year ending June 30, 1896, including labor, materials, and subsistence.

Quarrying stone, 7,938 cubic yards at	$0.68
Excavation, channel:	
Solid rock, 1,299 cubic yards, at	1.81
Loose rock, 63 cubic yards, at	.84
Riprap dam, 2,061 cubic yards, at	1.19
Riprap dam, 937 linear feet, at	2.63
Riprap on bank, 1,276 cubic yards, at	.28
Crib, with 874 cubic yards stone filling, 300 linear feet, at	4.63

The amount expended during the fiscal year 1895–96, including outstanding indebtedness, was $19,977.87.

The results obtained during the fiscal year at Caney Creek Shoals are, briefly: Lengthening the dam has given 1 foot more water in the channel and the new crossing is being used by steamboatmen in preference to the old one.

For details of work and costs, see appended report of Supt. R. R. Thacher (Appendix D).

There was expended under the original project to June 30, 1894, including outstanding indebtedness	$293,752.90
The estimate for improving Tennessee River above Chattanooga under the present project, adopted in 1894, exclusive of amounts already expended, amounts to	650,000.00
Amount appropriated since adoption of present project	65,000.00

Money statement.

July 1, 1895, balance unexpended	$43,694.80
Amount appropriated by act of June 3, 1896	15,000.00
	58,694.80
June 30, 1896, amount expended during fiscal year	17,453.43
July 1, 1896, balance unexpended	41,241.37
July 1, 1896, outstanding liabilities	2,524.44
July 1, 1896, balance available	38,716.93
Amount (estimated) required for completion of existing project	585,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	65,000.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

2. CHATTANOOGA, TENN., TO DECATUR, ALA. (149 MILES).

The serious obstructions to continuous navigation through this section of the river are Ross Towhead, Burris Bar, the Suck, Bridgeport Bar, Island Bar, Widow Bar, Gunters Reef, Beards Reef, and Flint River Bar.

The approved project for this section of the river is "to remove obstructions so as to secure a depth of at least 3 feet at low water.

The total amounts expended on this section of the river since July 1, 1891, are as follows:

Locality.	July 1, 1891, to June 30, 1895.	Year ending June 30, 1896.	Total for five years.
Ross Towhead	$23,768.67	.....	$23,768.67
Suck, including Tumbling Shoals, etc	56,168.50	$22.90	56,191.40
Bridgeport, Ala	37,490.04	9,144.20	46,634.24
Guntersville and Beards Reef	3,463.52	3,621.14	7,084.66
Total	120,890.73	12,788.24	133,678.97

This expenditure has resulted in the removal of bowlders, gravel, snags, etc., and upstream navigation has been rendered somewhat easier than it formerly was. The dangers attending downstream navigation have been materially, if not entirely, remedied. The work done has, however, unavoidably been entirely local in its character. There is no continuous survey and profile on this part of the river, although of the reach from Chattanooga to Bridgeport a complete map has been pieced together. During the year extensive repairs have been made to the entire fleet used on this section of the river. All work has been under the local charge of Asst. Engineer W. S. Winn, with headquarters at Bridgeport, Ala.

Ross Towhead.—This divides the river about 1 mile below Chattanooga into two portions; the right-bank chute, which was generally used during the medium and higher stages, was not navigable during low water because of rock ledges extending across to the towhead. Under the original project of improvement the left-bank chute was selected for navigation, and to increase the depth of water two ripan dams were built in 1873–74; one extended from the head about two-thirds across to the right bank; the other from the foot of the towhead downstream longitudinally for 400 feet. Gravel washed from above had accumulated at the foot of the longitudinal dam until at the close of the fiscal year 1893 a gravel bar connected its extremity with the left bank. Only about 18 inches were available at low water.

The Annual Report for 1894 says:

From the relative velocity and direction of the currents through the two chutes at Ross Towhead, at various stages of the river, it was evident that a sufficient depth at low water could not be maintained in the old channel to the left of the towhead, and this, together with the fact that the best water above and below the obstruction was along the right bank, led to the adoption of the new channel along the right bank. The channel was to be, when completed, 150 feet wide, straight throughout from deep water above to deep water below, and to have 3 feet depth at low water, the amount excavated being determined by a series of gauges located along the line of excavation. The old chute was to be closed by a riprap dam at the head of the island, formed by the excavated material, made tight by gravel backing, and raised to the height of 6-foot stage.

At the close of the fiscal year 1894 the work was being done by contract with W. A. Kirk, of Madison, Ind. The necessary drilling was done by hand from platforms when practicable, and when season and

stage of water permitted, by men standing on the river bottom, a tripod dam being used to break the force of the current. The ledges were blasted and material removed by dipper dredge. Low water delayed the work and the contract was extended to December 25, 1894. Work was resumed by contractor July 13, 1894, and closed down November 15, 1894; 1,842.58 cubic yards of rock were removed, at a cost of $3.75 per cubic yard, and 269 cubic yards of gravel, at a cost of $1 per cubic yard.

The monthly report for November, 1894, by the inspector, says:

A number of prominent steamboat masters and pilots visited the work and sounded over it. They were greatly pleased with the entire work, and all pronounced it to be one of the best chutes on the river.

During the week ending June 8, 1895, a steamboat with two barges in tow struck a rock and knocked a hole in the bottom of one of the barges. It is believed, however, that the boat was not in the channel, for no complaints have been heard since that time.

No work was done during the year.

Burris Bar.—Williams Island, about 7 miles below Chattanooga, divides the river into two chutes. The present low-water channel is the right-bank chute. This channel is obstructed by Burris Bar, consisting of ledges of rock entirely across the channel. The bar is about 1,800 feet across, up and down stream, and has an available depth at extreme low-water mark of about 1 foot. The left-bank channel is obstructed by a short reef at the head, and by snags and bowlders. No work of improvement has been done here.

The Suck.—This is the name commonly applied to the several rapids and shoals where the river winds in a tortuous route through the mountains below Chattanooga, covering a distance of 8.5 miles, in which the fall is 16.5 feet. The obstructions, separated by pools, are known as Tumbling Shoals, Suck Point, The Suck, Pot, Skillet, and Pan, and are formed by rock reefs and bowlders, and by projecting rocky points from both shores, which contract the waterway.

At low-water stages Tumbling Shoals and the Skillet are especially difficult to navigate. As the river rises, Suck Point and The Suck become difficult to stem, while the Pot and Pan are very great obstructions during high water.

The channel work carried on in 1869 and 1870 at the Suck and Pot, and in 1889 at the Pan, consisted in widening the cross-section by the removal of bowlders, projecting rocky points, and overhanging trees, and has resulted in somewhat diminishing the velocity of the current. But upstream navigation is still attended with delays, caused by the necessity of laying lines and warping vessels over the swiftest places.

During the year a large rock which had been knocked from the wall and which contained a ring bolt, formerly used for pulling boats up through the rapid current of the "suck," was blasted and removed from the channel, together with some smaller rocks, aggregating in all 5½ cubic yards, at a cost of $4.16 per cubic yard.

Total amount expended during the year was $22.90.

Bridgeport Reefs.—The river near Bridgeport, Ala., is divided into two chutes by Bridgeport Island, about 5 miles long, the left-bank chute being the steamboat channel. The obstructions consisted of a gravel deposit near the head of the island and limestone reefs above the railroad bridge and near the foot of the island.

At extreme low water the available depth was about 18 inches. The fall is about 1 foot to the mile.

During the fiscal year ending 1894 work at the head of the island resulted in a completed channel 120 feet wide and averaging about 6

feet deep. This increased depth was given to allow for drawing off the water, which will result when the bars in the same chute below are excavated.

Just above the railroad bridge one cut had been made through the bar at the close of the fiscal year 1894, resulting in a channel 1,800 feet long, 40 feet wide, and 5 feet deep.

Work was resumed here in November, 1894, and continued until the close of the fiscal year 1895, with many interruptions, due to cold weather and too high a stage of water.

The obstructions are gravel and bowlders, and the project is to dredge these out to form a channel 120 feet wide and 3 feet deep at low water and to make of the dredged material a longitudinal dam intended to confine the water to the narrow dredged channel and also to back the water up the chute. The excavation was found to be of the most difficult kind, the gravel being filled with large bowlders, which strained and often broke the dredge machinery, necessitating constant delay and repairs.

All the work has been done by hired labor, using the U. S. dredge *Harwood*, which is really too light for such heavy work. At the end of the first week in July the dredge broke down and was ordered to Muscle Shoals Canal for repairs, and before repairs could be finished the river had become too low to get it back. Nearly the whole working season was therefore lost, for it was not until January that a rise occurred sufficient to get the dredge back up the river. En route the dredge stopped to do some work at Flint River Bar, reaching Bridgeport in February. Only a few days' work was accomplished before high water compelled the tying up of the fleet. The dredge was again brought out on May 22 and worked continuously to the end of the fiscal year, except for a period of ten days, during which a new "A" frame was being erected and a new dredge dipper being made. One thousand four hundred and twenty-one cubic yards of bowlders and 3,104 cubic yards of clay and gravel were dredged from the channel, at a total cost of $1,318.76, or 29.2 cents per cubic yard. At the close of the fiscal year there remains about two more weeks' work for the dredge and derrick boat at this point. At the end of this time the channel at Bridgeport Bar will be 100 feet wide and 3 feet deep for a distance of 1,400 feet upstream from the bridge, except for a distance of 100 feet immediately on the reefs, where there will be at least 2½ feet at low water.

Island Bar.—This is 1.5 miles below the Bridgeport Bridge and extends half a mile downstream across both chutes. In the left bank chute the obstruction is solid limestone reef, crossing the chute at an angle, and about 600 feet across, up and down stream. Below this are bowlders, sand, and gravel.

The project is to excavate a channel 120 feet wide and 3 feet deep at low water.

During the fiscal year ending June 30, 1895, 889.7 cubic yards of solid rock and 21 cubic yards of gravel were excavated by drilling and blasting and removed by wheelbarrows, at an average cost of $4.16 per cubic yard for rock and gravel combined.

A tripod dam 180 feet long, in fifteen bays, was used to break the force of the current, and was moved four times as work progressed. This work has resulted in a channel 80 feet wide and 2 feet deep at low water for a distance of 600 feet, which is 12 inches more depth of water over the reefs than ever before. During the fiscal year no work was done, the fleet being engaged at worse obstructions.

Widow Bar.—This obstruction, a rock reef, is about 2.5 miles below

Bridgeport Island and is about 2,800 feet in length, the depth of water over it varying from 1.5 to 2.5 feet at low water.

Gunters Reef.—The river just above Guntersville was obstructed by bowlders and loose detached rock, making the steamboat channel very tortuous and difficult of passage during low water. Navigation was further impeded by a rock ledge 300 feet across, on which there was a minimum depth of 1 foot at low water. Work was begun here in the fall of 1892 under contract with Neely & Smith. Owing to sudden and frequent fluctuations in depth of water, which resulted in twice washing away a temporary dam placed to deflect the current so that the men could stand in the river bottom to drill, little work was accomplished by the contractors and two extensions of time were granted them. On application of the contractors and by authority of the Chief of Engineers it was proposed to complete this work by the aid of a United States dredge not in use, reasonable allowance being made for same. This dredge was on its way to this locality at the end of the fiscal year 1894.

Slow progress was made with the dredge, however, which was the same one used later at Bridgeport, as described above. The difficulties of the work were the same as described above for Bridgeport. The dredge was abandoned, and by November, 1894, the water had become too cold for laborers to stand in, and work here was abandoned by the contractors.

In August, 1895, the United States fleet, consisting of the steamer *McPherson*, derrick boat, three barges, and two cabin boats, were taken from Bridgeport to Gunters Reef and the work continued by hired labor. A tripod dam 160 feet long was put in, and notwithstanding a delay of nearly three weeks, on account of a rise, very good progress was made.

The contractors' greatest trouble had been to get explosives deep enough to do good execution, on account of sand and crumbled pieces of the top ledge filling the holes as soon as the drills were removed. This was overcome by using pieces of 2-inch pipe about 14 inches long. The bit of the first drill was made the same width as the outside diameter of the pipe. The hole was put down about 10 inches, the pipe inserted, and a drill with a bit to fit the inside of the pipe carried the hole down as deep as desired.

The material was easily drilled, a crew of three men drilling 50 feet of holes in one day. The strata were almost horizontal, consisting of rotten limestone, flint, and shale, with here and there pockets of fire clay and iron ore.

The old channel was both crooked and shallow. The project was to cut a straight channel through the reefs with a depth of 3 feet at low water.

Eight hundred and six cubic yards of rock, requiring 2,048 linear feet of hole to be drilled, were removed, at a total cost of $2,088.96, or $2.59 per cubic yard, which includes all expenses incurred in preparation and in working at this place.

The result of the season's work is a channel through the reefs 350 feet long, with a depth of 2½ feet at low water for a width of 60 feet, and a depth of 20 inches for an additional width of 60 feet. Although the project is not completed, the work done has facilitated navigation, and boats that formerly had to lay lines have since stemmed the current at the same stages of water with barges in tow.

Beards Reef.—This obstruction is about 3 miles below Guntersville Landing, and consists of a rock ledge crossing the river normal to its banks, with a gap near the right bank, used as a steamboat channel, but obstructed by detached rocks.

The old channel went from about one third across the stream above the reef to within 100 feet of the north bank at the reef, then with an abrupt bend crossed to the south bank. The project was to cut a straight channel through the reef and bar about 200 feet from the south bank, where the water is deep immediately above and below. The dredge was not available, but it was decided to blast and remove as much as possible of the solid reef with the steam derrick and to leave the rest to be picked up by the dredge. Work was begun September 21 and continued until early in October, when all the reef that appeared above the gravel had been removed.

Five hundred and one cubic yards of rock, requiring 1,437 feet of holes, were removed and placed along the sides of the excavation, at a cost of $1,704.63, or $3.40 per cubic yard. As the rock was of the hardest limestone and pure flint, a crew was able to drill only about one-third as much here as at Gunters Reef. Before the new channel can be used, the dredge will have to pick up the gravel and other loose material.

Flint River Bar.—This obstruction is about 20 miles below Guntersville, and was formerly the shoalest place between Guntersville and Hobbs Island. The transfer boat of the Nashville, Chattanooga and St. Louis Railroad Company always had difficulty here when the low-water season began. It was thought to consist entirely of loose material brought in by Flint River, but was later found to be underlaid by a rock reef. The dredge *Harwood*, en route to Bridgeport, worked here from January 7 to January 25, 1896, when high water caused a suspension of the work.

Ninety-two cubic yards of bowlders and 2,906 cubic yards of clay and gravel were dredged from the channel, at a cost of $785.53, or 26 cents per cubic yard. Two of the necessary four cuts were made with the dredge, and a depth of over 3 feet obtained, except for a distance of 40 feet up and down stream, which will require blasting.

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3. DECATUR TO FLORENCE, ALA. (48 MILES).

The principal obstructions are the Muscle Shoals, extending from deep water at Browns Ferry to deep water at Florence, a distance of 38 miles (only 8 of which are navigable), and embracing Elk River Shoals, Big Muscle and Little Muscle Shoals.

The object of the improvement is to make continuous navigation around these obstructions by means of a lateral canal.

The approved project according to which work is being done, based on the survey of 1872, and somewhat modified in 1877, is:

(1) To enlarge, rebuild, and straighten the old canal around Big Muscle Shoals, built for the United States by the State of Alabama in 1831–1836 and abandoned in 1837, by constructing a canal 14.5 miles long, having nine locks, with a total lift of 85 feet and an aqueduct 900 feet long and 60 feet wide over Shoal Creek, with the necessary permanent dams and bridges over the several creeks and ravines, the canal trunk to be from 70 to 120 feet wide at the water surface and 6 feet deep, and the locks 300 feet long and 60 feet wide, with a depth of 5 feet of water on the miter sills.

(2) To construct at Elk River Shoals a canal 1.5 miles long, with two locks, having lifts of 12 feet and from 8 to 11 feet, respectively, and of same dimensions as the locks at Big Muscle Shoals.

(3) To blast at Little Muscle Shoals a channel through the bed rock of the river and to construct stone wing dams and retaining walls to contract the waterway and to check the velocity of the current at certain points, as modified in 1880; to construct a lateral canal on the north bank, 15,000 feet long, with a guard lock at the head and a lock at the foot, having a lift of 12 feet and of same dimensions as the locks at Big Muscle Shoals.

Up to the close of the fiscal year ending June 30, 1895, $3,191,726.50 had been expended with the following results:

Big Muscle Shoals and Elk River Shoals divisions of the canal have been completed permitting navigation at all stages of the water; channels have been excavated through Browns Island Chute, Gilchrists Chute, and Nances Reef; houses have been built for occupancy of lock masters and assistants; a dredge and towboat constructed, and a large amount of plant purchased for the necessary and immediate uses of the canal.

The channel through Browns Island Chute is very crooked, and was meant to be only temporary, as being the quickest obtainable. The proper channel is the one proposed along the left bank of the river.

Gilchrists Chute and Nances Reef have only 18 inches over them at low water. Work must be done to increase this to at least 3 feet before the canal work already accomplished can be regarded as finished.

Through Little Muscle Shoals the water gets below 3 feet at low stages, but no extensive channel work is deemed advisable in view of the proposed lateral canal.

At several places in this section of the river, notably Little Muscle Shoals and Browns Island Chute, navigation is dangerous on account of concealed rocks and ledges near the edges of blasted channels. It is proposed to erect at each of these places, as a guide to steamboats, a triangular pyramid of heavy timber, about 12 feet on a side, filled with several tons of stone. One was erected during May, 1896, at the head of Little Muscle Shoals, and two during June at Nances Reef. They have proved valuable guides to pilots. They are painted black and surmounted by a box painted white, the top standing about 10 feet above low-water level.

At Sweetwater, 1 mile above Florence, is a gravel bar formed by the wash of a small winter torrent emptying into the chute at this point, which has given boats much trouble at low water. This will eventually have to be dredged out, although it is reported that after the high water of April, 1896, the point of the bar was found to be washed away and the channel much improved. Opposite the bar the current has cut into the bank of Pattons Island, and it is proposed to erect here a crib which will protect the island, straighten the channel, and direct the current on the end of the bar.

At the lower end of the canal, just outside of Lock 9, "Galloping Shoals," as it is called, formerly produced a strong eddy in the entrance pool below the lock, which caused sand and gravel to be deposited and made the entrance to the canal difficult and at times dangerous. It is proposed to remedy this by a riprap wing dam, starting opposite the lower corner of the lock and extending downstream at an angle of 40° with the lock axis for a distance of 350 feet. This project was approved May 7, 1895, and work was begun May 16, 1895. The dam was brought up to a height of 2 feet above mean low water and work was suspended November 5, 1895, in order to note what the effect would be before proceeding further.

It was found that at stages of the river from low water up to about

5 feet on the Lock 9 gauge, the dam as built cut off the eddy along the guide wall below the lock. Above this stage, however, the troublesome return current again sets in, increasing in velocity as the river rises. The spring high water reduced the height of the crest of the dam an average of 18 inches and made a breach about 5 feet in depth near the shore end. It is proposed to increase the height of the shore end of the dam to about 8 feet on the gauge and to slope it down to meet the present crest at a distance of about 150 feet from the shore end. For details of construction and cost of dam, see appended report of assistant engineer W. A. McFarland (Appendix E).

During the fiscal year there have been built at Lock 6, Muscle Shoals Canal, and paid for in part from the appropriation for improving the Tennessee River below Chattanooga, a sawmill and a dry dock. These are reported on under the head "Operating and care of Muscle Shoals Canal, Tennessee River" (Appendix A).

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4. FLORENCE, ALA., TO FOOT OF BEE TREE SHOALS (30 MILES).

Bee Tree and Colbert Shoals, beginning about 22 miles below Florence, form the principal obstructions to navigation during low water.

These shoals, which may be considered as forming one continuous obstacle, are 8 miles in length, with a total fall of 25 feet at low water, at which stage the available depth is about 1.5 feet.

Four islands divide the river through the shoals longitudinally, and the work heretofore carried on for the improvement of navigation consisted in building riprap dams which, in connection with the islands, confined the water to the chute along the north bank. Increased depth was obtained by channel excavation. This method does not give results adequate to the present needs of commerce.

The total amount actually expended on the improvement of these shoals from the beginning of improvement in 1827 to June 30, 1890, including surveys, excavation of rock from the channel, and construction of dams, was $62,243.41.

The project adopted in 1890 contemplates the construction of a lateral canal on the south bank of the river 7.8 miles long, 150 feet wide at the water surface, with a depth of 7 feet. A combined lock, with a total lift of 25 feet, was originally intended to be placed at the lower end and a guard lock at the head, for use when necessary at very high water, the locks to be 80 by 350 feet, with a depth of 6 feet on the miter sills at extreme low water.

This project was modified, after the detailed surveys of 1891 were completed, by substituting for the combined lock two locks of 12 and 13 feet lift, respectively, at extreme low water, separated by a pool 1 mile in length.

This project was again modified in 1892 by the substitution of one lock of 25 feet lift for the two locks contemplated in the project as modified in 1891, retaining the guard lock at the head of the canal.

A contract for the construction of the lift lock at Riverton, Ala., was entered into on August 10, 1893, with Tere A. Clark, of Quincy, Ill.

Operations under this contract were continued with ever-increasing difficulties and diminishing results until December 17, 1894, when the contractor ceased all active work, owing to a strike among his employees. The contract was annulled in January, 1895, and by February 1, 1895, the United States had assumed charge of the work. Comparatively

little had been accomplished by the contractor, his efforts having been principally confined to excavation of lock pit.

Under the project $149,735.42 was expended up to the close of the fiscal year, June 30, 1895, in making survey of location for canal, purchasing lands necessary for the improvement, examining foundations for both locks, in making detailed drawings and specifications for and purchasing lock-gate anchorages, in making detailed drawings of the lift lock and of special stones and other masonry, in beginning work of designing the guard lock, in bringing a good supply of water to the lock site, in erecting a pumping plant, two stiff-leg derricks, the necessary storehouses and shops, in opening a quarry at Cherokee, Ala., and in general preparations for the establishment of the plant to be used in carrying on the work.

All of the land intended for the right of way has been purchased except 2.24 acres, and the papers for this purchase are in the hands of the United States attorney.

GENERAL DESCRIPTION OF THE LIFT LOCK.

The detailed dimensions of the lock are given on plate No. 1. The principal dimensions are as follows: Total length, 551½ feet; length between hollow quoins, 350 feet; length between lower gates and guard gates, 40 feet: clear width, 80 feet; height of lock walls, 37 feet; height of lift wall, 25¾ feet; width of bottom course of lock walls, 21½ feet; width of bottom course of lift wall, 10 feet; width of coping course of lock walls, 5 feet; width of coping course of litt wall, 6 feet; width of bottom course of gate abutments, 34 feet; width of coping course of gate abutments, 30 feet.

There are fifteen courses, varying from 3 feet 6 inches to 1 foot 9 inches in thickness. The two lower courses are of limestone, as are also the fourteenth and fifteenth courses, the latter being the coping. All the remaining courses are of sandstone. The lift wall is of limestone, the courses varying from 3 feet to 3 feet 6 inches in thickness, except the coping, which is 2 feet 9 inches thick. The miter sill and miter wall are circular arcs, the upstream faces having a radius of 65 feet 1 inch. There will be three pairs of gates, upper and lower gates proper and lower guard gates. The form and dimensions of the culverts may be seen in the drawings.

PLANT USED IN CONSTRUCTION.

All work is done by hired labor. Practically the entire plant has been installed during the present fiscal year.

Water supply.—Water is obtained from a spring 2,300 feet south of the lock site, and is conducted by gravity through a 2-inch pipe to a 7,000-gallon tank in the material yard. This tank supplies eight boilers, aggregating 206 horsepower, and furnishes all the water needed for mixing concrete and mortar, for washing stone, and for drinking purposes. The discharge at the spring is 11.99 gallons per minute, and at the tank 9.67 gallons per minute, the head being 9.1 feet.

Pumping plant.—As originally erected by the contractor the pumping plant consisted of a 9-inch centrifugal pump, with a capacity of 2,600 gallons per minute, driven by a 35-horsepower stationary engine. A similar pump was purchased to provide against accident. These were interchanged for necessary repairs and successfully drained the pit, with a lift of 37½ feet, until February, 1896, when a break in the levee covered the centrifugal pump with quicksand and rendered it tempo-

rarily useless. A steam pump of the following dimensions was then purchased: Steam cylinder, 14 inches; water cylinder, 8 inches; stroke, 20 inches; suction, 6 inches, and discharge, 4 inches. The centrifugal pump was repaired and either it or the steam pump could be used. The total lift of the steam pump is 42¼ feet, the suction being 12½ feet. Under ordinary conditions pumping for four hours in each twenty-four keeps the pit sufficiently well drained.

During a second flood, in April, the centrifugal pump again failed and the pit was partly filled with water, as the steam pump could not do the work alone. Because of its inaccessibility for repairs, the centrifugal pump has been abandoned, and to provide against emergencies a duplex pump of the following dimensions has been purchased: Steam cylinders, 14 inches; water cylinders, 12 inches; stroke, 12 inches; suction, 10 inches; discharge, 8 inches; capacity, 1,170 gallons per minute. The steam pump is ample for ordinary service.

Traveling cable way.—The lock pit is spanned by a Lidgerwood traveling cable way, of 370 feet span, with a capacity of about 400 cubic yards per day of eight hours and a maximum safe load of 5 tons. The head and tail towers are 60 and 35 feet high, respectively, and are erected on counterbalanced cars, each of which moves on three parallel tracks extending the full length of the lock pit. An elevation of the cable way and general arrangement of the plant are shown on plate No. 2.* The cable way has an "aerial dump" attachment which makes it especially efficient in filling behind the lock walls. It is used for conveying all excavated material from the pit, filling behind the walls, moving engines, erecting construction derricks, and removing the damaged piling that surrounded the pit.

Construction derricks.—Masonry is laid with four stiff-leg derricks, each maneuvered by a 7 by 10 inch double-cylinder, double-drum hoisting engine. Their booms are 12-inch square timbers, 60 feet long, each trussed with four iron rods and capable of hoisting 10 tons.

Cable road.—All materials for construction are conveyed into the lock pit by an endless cable road, passing from the yards into the pit on an incline. The cable is a ¾-inch 7-wire cast-steel rope, 2,000 feet long, operated by a reversible link motion haulage engine with 10 by 12 inch cylinders. Steam is supplied by a 60-horsepower return tubular boiler, which also furnishes the pumping and shop engines.

Stone-yard derricks.—Four guy derricks are used for unloading, scabbling, and reloading the rubblestone. Two of these are maneuvered by hoisting engines and two by horsepower.

Traveling crane.—A traveling crane is used to handle all of the cut stone from the time it is received rough from the quarry until it is loaded for transferring to the lock walls. All its parts are of wrought iron, and it consists of a 14-foot mast and a 30-foot boom placed on a counterbalanced car. A double cylinder duplex hoisting engine controls all of its movements. Its maximum load is 10 tons, hoisting speed 13 feet per minute, and traveling speed 150 feet per minute. The track, 540 feet long and 12 feet gauge, is laid with 56 pound steel rails on stringers. The great weight of the machine has caused the rails to curve up at the ends. Heavier rails or a specially devised joint fastening should be used to prevent this. All parts of the crane are bolted together so that it may be easily taken apart.

Shops and storerooms.—Nearly all the necessary buildings were erected during the fiscal year 1895. During the present year an oil house has been erected and some minor improvements made in the tool room. A tooth-chisel machine was added to the shop appliances.

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* Not printed.

For details of cost of plant with cost of additions and improvements and maintenance, see appended report of Assistant Engineer S. B. Williamson (Appendix F).

Foundation.—The reference of the foundation is 0.5 foot above datum and an average of 6.5 feet below the surface of the solid rock. The rock has been excavated to the full depth for a distance of 8 feet back from the face of the wall. For the remaining distance the disintegrated portion has been removed, giving a solid foundation throughout. The rock (a blue limestone) is full of seams and unfit for a foundation for 2 feet below its surface. The remaining depth, as shown by frequent test holes drilled to 12 feet below subgrade, is hard and solid.

In the foundation of the upper gate recess of the south wall a test hole developed three horizontal seams, 4, 6, and 10 feet, respectively, below grade. The last seam was 5 inches wide and contained a stream of clear water, discharging at the surface approximately 15 gallons per minute. In order to examine minutely the foundation at this point a pit 8 feet square was excavated to the depth of the lowest seam. The upper seams disappeared within the excavated area and the walls presented a solid appearance for 10 feet in depth. The discharge from the remaining seam was confined within a small reservoir, from which it is allowed to escape through a 2-inch pipe leading to the surface in front of the filling culverts. The pit was refilled with rubble masonry and concrete.

The rock is in layers from 6 inches to 2 feet thick and dips to the southwest at an angle of about 10° to the horizontal.

In preparing the foundation it is found to be more expedient to excavate slightly below grade and to refill with concrete rather than to "bull point" the rock to the required grade. The surface of the rock is carefully cleaned and a thin layer of mortar is spread over it before the concrete is deposited.

Excavation.—The condition of the lock pit at the beginning of the present year is shown by the photograph taken May 17, 1895, and published in the Annual Report of the Chief of Engineers for 1895, opposite page 2304.

During July and August, 1895, a portion of the contractor's damaged pile revetment was removed from the south side and the bank was partly sloped. The embankment of gravel which the contractor had placed along the center line of the pit was moved to the north side, in order to clear the way for the cable road tracks. Only a small portion of the material excavated during these two months was removed from the pit, as it was considered more economical to simply transfer it to make space for erecting the plant and to afterwards rehandle it with the cable way rather than to elevate it a vertical distance of 30 feet at that time when wheelbarrows were the only available appliances. Since September 1, 1895, the cable way has been used for conveying all excavated material, for removing damaged piles, and for filling behind the lock walls.

Upon the failure of the timber revetment, the earth broke along the line of anchor piles 40 feet back from the face, and a wedge-shaped mass slid into the partly excavated pit. On account of this, and on account of the limited space on United States land for waste material, a large portion of the excavation has required rehandling. For example, the material removed from the site of the south wall was first conveyed to the north side of the pit and subsequently reloaded and placed behind the south wall as back filling.

The material is shoveled into wooden skips holding 2½ cubic yards,

which are picked up, conveyed to the desired point, and automatically dumped by the cable way. The solid rock after being blasted is loaded into the skips by hand.

The average depth of excavation is 38.1 feet, and the following are the kinds of material encountered, with their thicknesses: Surface soil, 7.3 feet: sandy loam, 11.3 feet; quicksand, 9 feet; gravel, 4 feet; solid rock, 6.5 feet. Water is found at an average distance of 20.3 feet above the surface of the rock.

The manifest failure of the timber revetment used by the contractor showed the necessity of adopting other methods for sustaining the sides of the pit. It was found that the quicksand would stand at a slope of 1 on 1 if kept drained, and the sides were therefore excavated at this slope throughout To prevent slides during wet weather a portion of the excavated rock was used to build a dry retaining wall 9 feet high and about 4 feet wide along the foot of the slope. This plan was most effective, except in one instance. During the flood of April, 1896, when the pit was partly flooded, the quicksand became so thoroughly saturated that about 1,000 cubic yards slid into the pit, carrying with it about 50 linear feet from the unfinished end of the dry wall.

During the fiscal year 8,042 cubic yards of solid rock and 51,097 cubic yards of earth and gravel were excavated; 23,295 cubic yards was used for back filling and 1,013 cubic yards for building levee and tracks.

Stonecutting.—5,328.43 cubic yards of limestone has been purchased from the contractor and from the receiver; 108 cubic yards of granite quoins has been purchased from the Southern Granite Company, of Lithonia, Ga., and 265 cubic yards of limestone coping from the T. L. Fossick Company, of Sheffield, Ala. The coping is delivered sawed one way and is dressed at the lock site.

All the remainder of the stone used is sandstone from the Cherokee quarry, and was cut by hired labor in the stone yard at Riverton.

Classification (fine pointed).—The face of fine-pointed stone is bounded by a chisel draft 1 inch wide and the remaining portion dressed to a true surface conforming to the draft lines, with no depressions greater than one-eighth inch. The face is finished with a tooth ax.

Rough pointed.—The plane of the face of rough-pointed work is fixed by a pitch line. There are no depressions below the pitch line and the projections do not exceed 1 inch.

Rock face.—The face of this class is surrounded by a pitch line that determines a plane below which there are no depressions. There are no projections over 4 inches.

Beds and joints.—The beds of the above classes are dressed throughout so as to be laid with $\frac{1}{4}$-inch bed joints. The vertical joints are similarly dressed for 12 inches back from the face, the remainder being roughly cut to form 1-inch joints.

Detail stones.—This class includes miter sills, coping, quoins, and arch stones. Their exposed surfaces are fine pointed and the beds and joints are cut throughout for laying with $\frac{1}{4}$-inch joints. With the exception of the coping of the straight wall between abutments, each stone of this class has been cut from detail drawings and patterns Granite quoins are delivered cut in accordance with patterns furnished by the United States. The surface of the hollow is finished with a patented eight-cut hammer.

Rubble.—The rubble backing is simply scabbled. The beds are scabbled for 1-inch joints and so are, as a general rule, the vertical

faces. Occasionally odd shapes necessitate larger ones. The quantities of the different classes cut during the year ending June 30, 1896, are as follows: Fine pointed, 2,259 cubic yards; rough pointed, 319 cubic yards; rock face, 12 cubic yards; miter sills, 80½ cubic yards; coping, 230 cubic yards; arch stones, 303½ cubic yards; rubble, 5,678 cubic yards; grooves, 998 square feet. Total number of cubic yards cut, 8,882.

For details of cost of cutting see tabulated statement in report of Assistant Engineer S. B. Williamson (Appendix F).

MASONRY.

The classification of masonry is similar to that of stone cutting above.

The various classes are built into the lock walls as follows: Fine pointed, in the sides of the culverts, in the tops of the square culverts, in the valve chambers, and in the exposed faces of the walls throughout, except the gate recesses; rough pointed, in the lower gate recesses and in as much of the upper gate recesses as is above the top of the well walls; rock face, in the upper gate recesses below the top of the well walls and in the wing walls below low-water plane; rubble, in the upper wing walls from the foundation to the upper level of the canal, in the well walls in front of the filling culverts, and in all other parts of the walls not otherwise specified herein. Sills include the miter sills and the lift wall. Quoins include the stones forming the curved surface of the hollow quoins and the pintle blocks. Coping includes the coping proper and the top course of the well walls. Concrete was used for leveling the foundation, filling large, irregular joints in the backing, and for filling behind the walls up to the surface of the solid rock. The spandrels of the arched culverts are filled with a layer of concrete 9 inches thick. All concrete was made with Portland cement. For the foundation the proportions used were 1 cement, 2 sand, and 4 broken stone. It was mixed comparatively dry, well rammed in place, and was flooded after the initial set. For filling joints and spandrels the proportions were 1 cement, 3 sand, and 5 broken stone, and for filling behind the walls 1 cement, 3 sand, and 7 broken stone.

The mortar used was made of Alsen's White Label Portland cement, and sand obtained from the Mississippi River at Memphis, Tenn. For the lower third of the wall, the proportions were 1 cement and 2 sand; for the remainder of the wall, 1 cement and 3 sand.

Methods.—The face stones are laid with ¼-inch beds and joints and the backing with 1-inch. The mortar beds are made full and comparatively soft, so as to insure a fine bed, and each stone is rammed in place. Vertical joints are filled with dry tamping mortar which is thoroughly compacted with iron rammers. Large, irregular joints in the backing are filled with concrete. The general practice is to lay each course with stones of equal height from face to back of wall. Two courses of backing are occasionally substituted, but only when a scarcity of the required height of stone necessitates it, as the two courses are more expensive.

Masonry work was begun on September 30, 1895. Until April 4, 1896, the work was confined to the south wall, but since this date both walls have been in progress. All masonry was abandoned from April 7 to April 20 on account of high water and an earth slide which entirely covered the small portion of the north wall that had been built.

The quantities of the different classes of masonry laid during the year ending June 30, 1896, are as follows: Concrete, 653 cubic yards;

fine pointed, 1,905 cubic yards; rough pointed, 330 cubic yards; rock face, 16 cubic yards; sills, 159 cubic yards; coping, 211 cubic yards; arch stones, 274 cubic yards; quoins, 34 cubic yards; rubble, 10,062 cubic yards. Total number of cubic yards laid, 13,644. The portions of the wall constructed are shown on the accompanying progress profiles, Plate No. 3.

For details of cost of laying masonry see report of Assistant Engineer S. B. Williamson (Appendix F).

OFFICE WORK AT RIVERTON.

Tests of cement.—In order to select a suitable cement, tests extending over a period of thirty days were made of the following brands: Portland cements, (A) Alsens White Label, (B) Dykerhoff, (C) Henry, (D) Grant, (E) Egypt, (F) Heyn Bros.; natural cements, (L) Union, (M) Diamond, (N) Star, (O) Black Ball, (P) Utica.

Seven and twenty-eight day tests were made according to the methods laid down by the American Society of Civil Engineers, and the results of the tests are shown in report of Assistant Engineer S. B. Williamson (Appendix F). Results are also shown graphically on plates 4 and 5 accompanying.

No extensive tests have been made during the progress of the work, but a number of barrels from each car load received are tested for time of setting, checking, and strength. Five thousand eight hundred and seventy-two barrels of cement and 1,821.4 cubic yards of sand have been received during the year.

Drawings and patterns.—The following drawings have been made: General working drawings for the various portions of the south wall and for the west end of the north wall; detail drawings of the recesses, culvert piers, arch stones, and of special stones for the south wall and miter wall, including the coping; and working drawings for the erection of the upper gate anchorage and for making the snubbing hooks.

Patterns have been made for the arch stones, miter-wall stones, wing-wall stones, and special recess stones.

Progress of construction is platted monthly on profile sheets, and monthly photographs are taken.

Lock gates.—The existing designs for the lock gates were perfected only so far as was necessary to ascertain the strains produced upon the anchorage. It is proposed to give the gates a curved form, and a design is now in progress for a gate constructed with top and bottom chords and heavy vertical frames diagonally braced. On account of the great length of the gates as compared with the height this form is thought to be the most economical.

MISCELLANEOUS WORK.

Gate anchorage.—The parts of the anchorage that are to be embedded in masonry were received during the last fiscal year. The anchor bars for the upper gate have been built into the south wall.

Snubbing hooks.—Nine snubbing hooks have been made and built into the south wall and four made and built into the north wall. Details of upper-gate anchorage and of snubbing hooks are shown on accompanying Plate No. 6.*

Canvas dam.—The lock site is surrounded by a levee for protection against high water, except for a distance of 180 feet on the west side, which space is left open to admit railroad tracks and wagon roads into the yards. When necessary this opening is closed by a canvas dam,

* Not printed.

180 feet long and 10 feet high, made of 12-ounce duck. A number of triangular wooden frames held together by longitudinal pieces and sheeted with 1-inch lumber furnish the support for the canvas. It requires about six hours to erect the dam. During the past year it was placed in position twice and the greatest head to which it was subjected was 39 inches. It proved very effective.

Other miscellaneous work consisted in building and repairing levees, clearing the steamboat landing, destroying a sunken barge at Riverton Wharf, unloading stone for the contractor, unloading coal, sand, cement, and stone, pumping the pit, moving derricks, making ditches around lock pit and yards, maintaining tracks and machinery, extending track for traveling crane, and sharpening and repairing tools.

There were no serious accidents to employees nor injuries to the plant during the year.

Twenty-nine working days were lost; 6 on account of legal holidays, 11 on account of high water, 2 on account of failure of water supply, and 10 on account of inclement weather.

CHEROKEE QUARRY.

Cherokee Quarry is a formation of light-colored siliceous sandstone, located on top of a range of hills 2½ miles east of Cherokee, Ala. It is elevated about 300 feet above the plane of the adjacent country and the deposit extends one-half mile along the ridge with an average width and height of 65 feet and 46 feet, respectively.

A greater amount of stripping and waste has been necessary than was indicated by the preliminary examinations. Frequently ledges which presented a solid face were found to contain irregular seams in the interior. Vertical seams extending from top to bottom divide the ledges into rectangular prisms with superficial areas varying from 800 to 2,000 square feet.

The sandstone rests upon a layer of earth 15 feet thick, which overlies a dark-gray limestone.

Cherokee is 18 miles from Riverton, and the stone is transported to the lock site over the tracks of the Memphis and Charleston and Northern Alabama railroads.

The inaccessibility of the quarry necessitated the construction of a spur track from the Memphis and Charleston Railroad 1 mile long (including a siding at the upper terminus), with a uniform grade of 3 feet in 100 and a maximum curve of 8 degrees. The track could not be brought nearer to the quarry than 700 feet horizontally and 140 feet vertically without the construction of an additional mile of track with a "switch back," over very rough ground.

The stone is therefore taken from the quarry tramway cars and loaded directly upon the railroad cars by a Lidgerwood suspension cableway.

The cableway is 700 feet long and has a capacity of 8 tons. The head tower is 60 feet high and at an elevation of 158 feet above the tail tower, which is 80 feet high. A 50-horsepower engine with 10 by 12 inch double cylinders and 54-inch drums is used.

The number of cubic yards loaded during a day is determined by the amount that may be received at Riverton. Usually 80 cubic yards is loaded in eight hours and the cost of operating the cableway is $11, or 13¾ cents per cubic yard loaded. Under more favorable conditions for receiving stone an average of 150 cubic yards per day could be loaded, reducing the unit cost to 7⅓ cents. The stones quarried average 1½ cubic yards.

The water for the boiler, for quarrying, and for drinking purposes is obtained from a spring 4,000 feet from the quarry, through a 1-inch pipe.

Methods.—The erection of the plant was completed in July, 1895. For the first two months quarrying was done by means of plugs and wedges; but since then the Knox system has been used exclusively, and a great saving in cost of quarrying and in wasted material has resulted. Part of the stripping has been used for ballasting the railroad tracks and for the embankments upon which the tramway tracks are extended. Three guy derricks maneuvered by horse power are used for handling the stone and loading it on cars for transportation to the cableway. All work has been by hired labor.

Work done during the year ending June 30, 1896, is as follows:

One thousand two hundred and seventy-three cubic yards of excavation for railway tracks and for increasing the clearance under the cableway, 6,000 feet of track laid, 900 cross-ties made, 43,192 cubic yards of stripping, 11,273 cubic yards of stone quarried, 2,694 cubic yards of stone scabbled, and 11,448 cubic yards of stone loaded on cars for shipment.

The stripping has been kept well in advance of the quarrying, and there is approximately 7,000 cubic yards yet to be quarried, with but little further stripping.

The average costs per cubic yard are as follows: Stripping, 29 cents; quarrying (including royalty for use of Knox system), $1.03; scabbling, $1.08, and loading for shipment, 18 cents.

The following miscellaneous work was done: Erecting a blacksmith's shop, a powder magazine, a tool house, an office, and a shed over cableway machinery; hauling machinery and materials to the quarry; cutting and hauling derrick timbers; maintaining tracks and machinery, and repairing and sharpening tools.

UPPER OR GUARD LOCK, COLBERT SHOALS CANAL.

At the beginning of the fiscal year Assistant Engineer D. W. Church was engaged on plans and estimates for the construction of this lock. These were completed on March 5, 1896. It is proposed to have other plans and estimates made, embodying a change in the method of filling the lock, before submitting the project to the Chief of Engineers for approval. Work is also in progress on designs for the gates of this lock.

The following photographs accompany the report:

Plate No. 7.* Pit of lift lock at Riverton, Ala. Looking down. August 31, 1895.
Plate No. 8.* Head tower of suspension cableway at Cherokee Quarry. September 3, 1895.
Plate No. 9.* Tail tower of suspension cableway and upper end of spur track at Cherokee Quarry. September 4, 1895.
Plate No. 10.* Traveling cableway at Riverton, Ala. Looking south. October 2, 1895.
Plate No. 11.* South wall of lift lock at Riverton, Ala. Looking up. November 7, 1895.
Plate No. 12.* Traveling crane and stone yard at Riverton, Ala. November 8, 1895.
Plate No. 13.* South wall of lift lock at Riverton, Ala. Looking up. January 6, 1896.
Plate No. 14.* South wall of lift lock at Riverton, Ala. Looking down. March 9, 1896.
Plate No. 15.* South wall of lift lock at Riverton, Ala. Looking down. April 7, 1896.
Plate No. 16.* South wall of lift lock at Riverton, Ala. Looking down. May 13, 1896.
Plate No. 17.* North wall of lift lock at Riverton, Ala. Looking up. June 30, 1896.
Plate No. 18. General view of lift lock at Riverton, Ala. Looking down. June 30, 1896.

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* Not printed.

5. FOOT OF BEE TREE SHOALS, ALABAMA, TO PADUCAH, KY. (225 MILES).

Information pertaining to the section of the river below Bee Tree Shoals (Riverton, Ala.) is very limited. In 1864–65 a reconnoissance of the Tennessee River from Paducah to Florence (225 miles) was made by a party of the United States Coast Survey, the data thus obtained to be for the use of the Mississippi Squadron under the command of Acting Rear-Admiral S. P. Lee, U. S. N. The "notes" pertaining to the map of the survey state that—

> The stages of water in the Tennessee may be divided into low, ordinary, and high water. A low stage of water prevails under usual circumstances for three months of the year; a medium or ordinary stage lasts generally five months, and a high stage four months.
>
> The average depth of the river at a low stage is on all the bars 3½ feet, excepting Duck River Shoals and Big Bend Shoals, on which 6 inches less is found at such a stage. This applies, however, only to the river below Chickasaw. The average depth at a medium stage may be considered 9 feet on the bars. At this stage only the Green Bottom Bar is bare.

Green Bottom Bar, Duck River Shoals, and Big Bend Shoals, above referred to, are distant 88 miles, 108 miles, and 199 miles, respectively, from mouth of river. Chickasaw settlement, 225 miles, is now known as Riverton, Ala. This section of the river has been heretofore covered by the estimates, surveys, and appropriations for the Tennessee River below Chattanooga, but no special allotments were made for the river below Bee Tree Shoals from the allotments for the Tennessee River made from the general appropriation acts of 1868 and 1869, or from the appropriations from 1870 to 1892, inclusive, aggregating the sum of $4,186,573.

A survey was completed in December, 1867, from Chattanooga to mouth of river, and an estimate of $40.000 submitted for removal of obstructions and construction of wing dams below Florence, 225 miles. (Report of Chief of Engineers, 1870, p. 389.)

Maj. Walter McFarland, Corps of Engineers, speaking of the lower Tennessee, in his report on lines of water communication between the Mississippi River and the Atlantic (Report of Chief of Engineers, 1872, p. 513), states that—

> Descending the river we find that improvements of some kind or other, removing rock or gravel or constructing wing dams, in order to straighten or widen the channels or to give them sufficient depth, will be required at the following points, viz: Bear Creek Shoals, Indian Creek, Big Bend Shoals, Diamond Island, Wolf Island, Chalk Bluff, Beach Creek Shoals, Buffalo Shoals, Armstrongs Towhead, bridge at Johnsonville, Duck River Shoals and Suck, Turkey Island Shoals, White Oak Island, Harrican Island, Leatherwood Shoals, Sandy Island, Panther Creek Island, McCulloughs Bar, Blood River Island, Pentecost Towhead, Widow Reynolds Bar, Grubbs Towhead, Little Chain, and Grand Chain.

In 1878 and 1879 some work was done at Duck River Shoals, 117 miles below Bee Tree Shoals. This shoal is a gravel bar, and is subject to considerable change from the action of the current. In 1881 and again in 1890 a small force with a snag boat was employed a short time in each year removing from the channel a large number of snags and overhanging trees. In 1882 the following localities below Rockport, about 4 miles below mouth of Duck River, were reported as requiring improvement: Duck River Suck, Johnsonville, Reynoldsburg Island, Turkey Island, Sandy Island, Little Chain, and Big Chain. It is stated in the Annual Report of the Chief of Engineers, 1892, page 1915, that—

> During the last fifteen years the improvement of the river below Bee Tree Shoals, and in fact below Florence, has not received the attention its commerce and naviga-

tion appear to be justly entitled to, owing to the almost imperative necessity of concentrating all efforts and expending all money appropriated for the river "below Chattanooga" upon the removal of the main obstruction to navigation, the then impassable barrier of the Muscle Shoals. However, during that fifteen years a small amount of work was done, as above stated, below Riverton, foot of Bee Tree Shoals, Alabama.

In 1878 and 1879, in the channel at Duck River Shoals, amounting to	$7,304.95
In 1881 and 1882, snagging, etc	3,373.04
In 1890, snagging, etc	1,365.33
Total below Bee Tree Shoals from 1875 to 1891	12,043.32

For the above reasons stated and from information received from various sources, it is believed that the condition of the lower Tennessee demands an accurate survey. The Muscle Shoals Canal, opened to navigation November 10, 1890, and the work now in progress at Colbert Shoals and Bee Tree Shoals, make it very important that the lower Tennessee River, from the foot of Bee Tree Shoals to the mouth of the river, be put in such condition as to permit the safe passage at all seasons of any boats capable of navigating the Muscle Shoals Canal and the proposed Bee Tree and Colbert Shoals Canal now in course of construction. In order to accomplish this it will be necessary to have an instrumental survey made of this section as soon as possible, to obtain detailed maps of the obstructions, with a complete profile of the river, so that estimates can be made and project for the radical improvement of the river below Riverton, Ala., be submitted, based upon the necessary and definite data that can only be thus obtained.

If the Tennessee below Bee Tree Shoals is to be radically improved it is necessary, as above suggested, that an instrumental survey be made as soon as practicable, for the reason that the surveys, so called, heretofore have been rapid reconnoissances or examinations, and do not furnish the data necessary whereon to base an economic, advantageous, and energetic prosecution of any work of improvement that may be projected.

The act of Congress of August 17, 1894, in appropriating $100,000 for the improvement of the Tennessee below Riverton, provided that of this sum "$90,000, or so much thereof as may be necessary, shall be used in the removal of snags and other obstructions to navigation between Riverton and the mouth of the Tennessee River, and the remainder of said sum of $100,000, or so much thereof as may be necessary, shall be used in making a survey of said Tennessee River below Riverton and submitting plans for its improvement."

SURVEY BELOW RIVERTON.

The survey authorized by above act of Congress was begun by a party organized November 17, 1894, at Riverton, Ala., under direction of Lieut. James F. McIndoe, Corps of Engineers. On account of the low stage of the river the supplies for the party could not reach Riverton, and actual field work was therefore begun on November 22, at Hamburg, Tenn., about 25 miles below. By December 17, 1894, the party had reached Grand View Landing, a distance of 37½ miles, when a rise in the river made further progress impossible and the field work was closed for the season.

Early in August, 1895, the river had reached a favorable stage, and a party was sent into the field under Assistant Engineer F. B. Williams. The stretch from Riverton to Hamburg was first surveyed and then the work was taken up where the party of the year before had left off. The banks of the Tennessee River are very heavily wooded and grown up with cane and underbrush, which makes it difficult to run a line along it. The season was very unhealthy and at times as many as ten or twelve members of the party were unable to work on account of malarial sickness. Notwithstanding these difficulties very good progress was made. Field work was stopped on November 23, 1895, at Fort

Henry, about 60 miles above Paducah, Ky., on account of want of sufficient funds to continue.

The following is a summary of what was accomplished:

	Right bank.	Left bank.
Miles of stadia lines run	134.9	137.9
Number of courses	1,297	1,274
Miles of level lines run	130.7	132.4
Number of bench marks established	104	118

One thousand and forty-eight ranges were sounded, covering a distance of 146.4 miles, including island chutes. Nineteen borings were made and located.

The assistant engineer and two computers were retained in the office for reducing the field notes and for making the maps. At the close of the fiscal year, June 30, 1896, the latitudes and departures of all the courses have been computed and the azimuths and distances adjusted. The level notes have been checked and all soundings reduced to low water.

The stretch from Riverton to Paducah will be comprised on 46 charts, each 36 by 24 inches inside the border, platted to the scale 1 inch = 500 feet. Twenty-eight of these maps have been completed. On each chart the low-water shore lines and the tops of banks are represented by full lines. On the banks 10-foot contours, with low-water surface as zero, are represented by fine lines. Figures at intervals indicate height of bank above low-water plane. The location and elevation of all bench marks are shown, as are also as many details of the banks and bed of the river as were obtainable.

The Chief of Engineers has authorized the completion of the remaining 60 miles of field work and the preparation of the maps to be paid for out of the general appropriation for this section of the river. This work will be completed during the next fiscal year.

For details of organization of survey party and methods of field work see appended report of Assistant Engineer F. B. Williams (Appendix G).

REMOVAL OF OBSTRUCTIONS.

The act of August 17, 1894, appropriated "$90,000, or so much thereof as may be necessary," for the removal of snags and other obstructions to navigation below Riverton. The United States possessed no plant for carrying on this work; but, in order to give temporary relief to navigation, a steamboat and a derrick boat were chartered in October, 1894, and by December 18, when a rise in the river made further work impossible, they had succeeded in removing many of the worst snags and other obstructions as far up as Savannah.

During the low-water season of 1895 the officer in charge entered into correspondence with numerous owners of steamboats and snagging plants, with a view to chartering a plant suitable for this work; but no arrangements could be agreed upon that would be economical and advantageous to the United States. During the year a tow boat has been built for work on this section of the river and a snagging barge begun. As soon as the river reaches a favorable stage the work of removing obstructions will be continued.

LIVINGSTON POINT, KENTUCKY.

Livingston Point is a narrow strip or tongue of land lying between the waters of the Ohio and Tennessee rivers, just above the mouth of the latter stream. This point and two small islands below it form the harbor of Paducah, and by their position prevent the ice-bearing current of the Ohio from entering the harbor, which is supplied with the warmer waters of the Tennessee, flowing from a southern latitude and rarely, if ever, troubled by ice.

The currents of the two streams are parallel for about a mile on either side of Livingston Point, and the Ohio River is rapidly encroaching upon this narrow barrier. The Tennessee River does but little damage. Near the extreme end of the point the Ohio has washed through at high water.

Allotments from the appropriations for improving Tennessee River below Chattanooga, to be used at Livingston Point, Kentucky, at the mouth of said river, have been made as follows:

Act of September 19, 1890	$25,000
Act of July 13, 1892	25,000
Act of August 17, 1894	25,000
Total	75,000

A survey of Livingston Point was made in December, 1890, and, based upon the data thus obtained, a project for its preservation, with an estimate of $180,000, was submitted January 12, 1891, to the Chief of Engineers, which was approved by the Secretary of War on the 16th of the same month.

As stated in the Report of the Chief of Engineers, 1891, page 2256—

The plan of improvement adopted for preserving this point from destruction consists in covering the wearing slopes with a revetment of stone and brush, carried well down the bank below the water surface, supplemented by a pile and stone dike along the crest of the weakest portion of the line, where the current of the Ohio has already cut through at high stages of the river, the object of both works being to hold in its present position the land now existing, and to cause, if possible, a further deposit of sediment on the Tennessee side of the dike, which, from the present indications, is likely to occur.

The revetment of stone and brush is specially needed on the Ohio side and will be but sparingly required on the Tennessee side. It will be carried well below low water, where it will consist of brush weighted down with stone, in alternate layers. From low water to foot of dike broken stone will be carefully placed.

The amount expended, including outstanding indebtedness, to the close of the fiscal year ending June 30, 1895, was $53,939.91, which has secured the completion of the dike on the Ohio side, across the "washout" near the extremity of the point, for a distance of 660 feet, and the protection of the bank for a length of 2,330 feet, extending 632 feet above the dike and 1,038 below it, the average width being 47 feet, all the work being done on the bank facing the Ohio River, so as to protect at once the low part of the exposed strip or "point," which was in danger of washing away. The work under contract for the shore protection of the Ohio bank of Livingston Point, by building a revetment of brush and stone riprap, was carried on in December, 1892, and from April to September, 1893, 9,092 cubic yards of stone, at $1.23 per cubic yard, and 274 cords of brush, at 94 cents per cord, being used, at an aggregate cost of $8,979.90. This contract was completed and terminated November 9, 1893, in accordance with its terms.

During an examination of Livingston Point, in July, 1893, it was found

that unusually heavy ice and high water had greatly injured the point by causing the wearing away of the Tennessee bank to an alarming extent. It was recommended that the Tennessee bank be also suitably protected by stone riprap. This work was approved and authorized to be done by hire of service and purchase of materials in open market. During the months of August and September, 1893, and January, 1894, 9,116.48 cubic yards of stone was placed as riprap protection to the Tennessee bank, at a cost of $1.23 per cubic yard, $11,213.26.

On the 21st of March, 1895, a letter was received from the city engineer of Paducah, Ky., in the name of the city council and others, reciting the danger of the wasting away of Livingston Point and the consequent destruction of the harbor of Paducah. A few days later Assistant Engineer D. W. Church was sent to make an examination and report. The river at that time was too high for a careful examination of the revetment work, but there seemed to be a break on the Ohio side about 50 feet long at a point 200 feet below the lower end of the dike. There had been considerable erosion at the head of Tennessee Island, and as the chute between the towhead and the Kentucky shore seemed to be filling up, it was feared that the Tennessee River might form a complete junction with the Ohio at the head of the island, and the combined streams flow past Paducah on the north side of Tennessee Island, transforming Paducah Harbor into a lake with entrance only at the lower end. This would be a serious calamity for the steamboat interests of the three great rivers, as Paducah has always been famous as a safe winter harbor. Nothing could be done during the high water.

In order to determine on the best plans for securing Livingston Point, a survey was authorized by letter of the Chief of Engineers dated November 21, 1895.

A party was in the field under Assistant Engineer D. W. Church from December 9 to 19, 1895, and made a careful survey covering 9½ miles on the Ohio River and 3 miles on the Tennessee. A comparison of the partial sections taken around Livingston Point with those taken in 1893 shows that no important change has taken place. The stone revetment which covers Livingston Point for a length of about 3,000 feet from its lower end was in fairly good condition and no trace could be found of the break reported in March, 1895. Some slight repairs are needed where the stone has been displaced in the revetment and where a pile is broken in the dike. The owner of Tennessee Island reported that the bank at the head of the island receded at the rate of 20 feet per year.

The chute, reported as filling up in March, was entirely dry in December for some distance at the head. The filling is hard and compact gravel, nearly level, at an elevation of about 7 feet above a zero stage for three-fourths of the distance southeasterly from the towhead to the main shore. Within the remaining distance there is a depression which will allow the water to flow through the chute at all stages above 3½ feet. For report on the survey see appended report of Assistant Engineer D. W. Church (Appendix H).

Since the survey nothing further has been done at this point, as the Ohio River has remained too high. As soon as a favorable stage is reached a plant will be chartered and the necessary repairs made by hired labor.

Map of Livingston Point and vicinity accompanies this report. (Plate No. 20.)*

Amount expended during the fiscal year 1895–96, $1,196.14; balance on hand, $19,863.95.

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* Not printed.

APPROPRIATIONS.

March 2, 1827	$200.00	March 3, 1881	$250,000.00
August 30, 1852	50,000.00	August 2, 1882	250,000.00
June 9, 1860	1,350.00	August 7, 1882	3,970.18
June 12, 1860	1,406.94	July 5, 1884	350,000.00
July 25, 1868	85,000.00	August 5, 1886	262,500.00
April 10, 1869	5,095.00	August 11, 1888	250,000.00
July 11, 1870	80,000.00	September 19, 1890	475,000.00
June 10, 1872	50,000.00	March 17, 1891 (transfer settlement)	3.91
March 3, 1873	100,000.00	July 13, 1892	500,000.00
June 23, 1874	100,000.00	August 17, 1894	400,000.00
March 3, 1875	360,000.00	June 3, 1896	50,000.00
August 14, 1876	255,000.00		
June 18, 1878	300,000.00		
March 3, 1879	210,000.00	Total	4,689,526.03
June 14, 1880	300,000.00		

Money statement.

July 1, 1895, balance unexpended		$686,737.54
Amount appropriated by act of June 3, 1896		50,000.00
		736,737.54
June 30, 1896, amount expended during fiscal year		263,572.31
July 1, 1896, balance unexpended		473,165.23
July 1, 1896, outstanding liabilities	$29,450.38	
July 1, 1896, amount covered by uncompleted contracts	9,000.00	
		38,450.38
July 1, 1896, balance available		434,714.85
Amount (estimated) required for completion of existing project		5,437,939.81
Amount that can be profitably expended in fiscal year ending June 30, 1898		1,000,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.		

Abstract of proposals for construction of towboat, opened at United States engineer office, Chattanooga, Tenn., at 12 m., Monday, March 16, 1896, by Capt. Dan C. Kingman, Corps of Engineers.

No. of bid.	Name and address of bidder.	Amount of bid.	Remarks.
1	A. R. Perry, Chattanooga, Tenn	$9,450	
2	Ed. J. Howard, Jeffersonville, Ind	9,000	Lowest bid.

Amount authorized to be expended, $9,500.

APPENDIX B.

REPORT OF MR. O. W. FERGUSON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., December 19, 1895.

SIR: I have the honor to make the following report on field and office work of precise levels:

As ordered by Capt. Theo. A. Bingham, Corps of Engineers, I organized a precise-level party in Corinth, Miss., on the morning of April 20, 1895.

The observers were Mr. F. B. Williams and myself.

The recorders were N. E. Ferguson and W. H. Henby.

These with four rodmen and four axmen made up the party.

The members of the party were allowed extra compensation for subsistence, and lived in the towns or with the farmers near the line of work.

It was expected that the party would be granted the use of a hand car to go to and from work, as has been done in three previous seasons, but the Memphis and Charleston Railroad Company would not allow its use and no available means of transportation were furnished. Several times when the distance was great, and the the time of trains suitable, we used the trains. When on the line of railroad we wished to move to new quarters, one man was always sent ahead with the baggage on the train. When not working along the railroad, a teamster with team was hired for moving and a member of the party sent along with the outfit.

The United States Coast and Geodetic Survey, on their line from Mobile, Ala., to Odin, Ill., established two permanent bench marks in Corinth, Miss., in the year 1889 and they also ran a line of precise levels in 1890 and 1891, from these two bench marks, V and W, in Corinth, to Memphis, Tenn., where they tied on to the "U. S. permanent bench mark, Memphis," of the line along the Mississippi River.

ROUTE.

The line of this work was, from Corinth to Riverton Junction, Ala., along the line of the Memphis and Charleston Railroad (30 miles); thence to Riverton, Ala., along the line of the Birmingham, Sheffield and Tennessee River Railroad (11 miles); thence up the river past the lower *lock of Colbert Shoals Canal* to the stone post marking the south corner of the United States building reservation (2 miles); then from Riverton Junction through Tuscumbia to Florence (28 miles), running also a side line from Prides Station to the Tennessee River (1 mile). The line crossed over the Memphis and Charleston bridge at Florence to the north side of the river; thence it proceeds up the north bank to and over the line of the Muscle Shoals Canal to opposite Weavers Island, a mile above Nances Reef, where the work crossed to the south side of the river and proceeded over the line of the Elk River Canal to Decatur, Ala. (51 miles). Having completed the work at Decatur, the party was ordered back to Riverton, to take up the line there and continue it down the left bank of the river. Lieut. James F. McIndoe, Corps of Engineers, ordered the field work closed by the end of July.

We completed the work to a point 4 miles below Pittsburg Landing (33 miles), and tied it up on four bench marks made on four different trees. The party then returned to Riverton on the steamer *City of Sheffield*, arriving there on the evening of July 31, and was disbanded.

Seventy-two miles of the line followed railroads and 93 miles were through the country along the river.

I returned to the office in Chattanooga with the note books, instruments, and engineering property. Mr. W. H. Henby, recorder, was retained to assist in the office computation of results, but shortly afterwards resigned, when Edgar C. Thompson, rodman, was employed for that work.

In carrying precise levels the most practicable route is often not the shortest. Good ground to work on is of prime importance. More error will arise from one setting of instrument or rod on springy or fibrous ground than from a half dozen on suitable ground. Railroads, wagon roads, and paths furnish the best ground, but with time and care good settings may be obtained under almost any conditions.

INSTRUMENTS.

The instruments used were Kern precise levels, tubes, and leveling rods, the same make as those used in all of the work done by the Engineer Corps in the Mississippi Valley. They are briefly described in the Report of the Chief of Engineers for 1884, page 2461. The aperture of the telescope is $1\frac{17}{16}$ inches, focal length $14\frac{1}{2}$ inches, and magnifying power of telescope 52 diameters.

A very great aid to convenience of observing and to accuracy of results is the mirror standing over the tube at an angle of about 35°, reflecting a perfect view of the bubble and scale to the left eye of the observer, while the right eye is in perfect position to read the wires on the rod through the telescope. There is therefore no necessity of anyone moving during observation, and the observer makes the complete observation-of both bubble and wire readings unaided. No target is used.

The three legs of the tripod unite in a broad triangular base under the instrument, each leg provided with a large thumbscrew which, when turned up, makes the tripod very steady.

The telescope has three horizontal wires, nearly equally spaced, and one vertical wire.

The spirit-level tubes are three-fourths of an inch in diameter and 6 inches long, and are divided each side of the center on a scale cut into the tube in divisions of $2\frac{1}{4}$ millimeters each. The tubes have a curvature of about $2\frac{1}{2}$ seconds per division.

It has generally been held by precise-level men that a value of three seconds for one of these divisions is about the best curvature for the tube; that much greater curvature made the bubble too slow and much less made it too unsteady; but my

convictions are that a curvature of one second per division is better than anything greater.

The rods are of a T cross section, which prevents them from warping, and are very perfectly graduated to centimeters, the millimeters and smaller parts being estimated in the reading. Estimating to tenths is quite natural, and by eliminations and comparisons the total error of estimating the three wires will usually not be greater than a half of a millimeter, and this being divided by three in the "mean wire" the error in estimating is commonly not larger than 0.2 of a millimeter, and these errors are compensating. This is closer than a target could be set, even if the observer could set his own target at will.

In good observing the error of estimating is within the error of manipulating the bubble and as much so in poor work.

Each rod is provided with handles and a watch level, which is adjusted every day to a plumb line hanging parallel to the axis of the rod. By this level the rod is kept vertical.

The instruments used were levels Nos. 2 and 3, level tubes Nos. 5 and 9, leveling rods Nos. X, XIII, XV, and XVI.

The rod supports or turning points are of the greatest importance, as everything depends upon their stability.

I designed a third variety of the pin for this work and it is superior to either of the former. A large pin disturbs the ground too much and too far around, causing reaction that does not subside at once. Again, if the taper of the pin is not quite gentle, after being driven into tight ground that furnishes a good lubricator, it will heave or slip back a small amount.

The least coefficient of friction of smooth iron against smooth wood, with the best lubricator, is 0.07, which is equal to an angle of repose of 4° 06′.

The total length of this pin (see figure) is 10 inches and the depth of its head is $1\frac{1}{4}$ inches. The taper of this pin for the $8\frac{3}{4}$ inches, from shoulder to point, between its axis and its elements if it were all one taper would be 3° 05′, hence it would not slip under the most unfavorable circumstances. In fact, seven-sixteenths of an inch of the taper is taken up in the first inch in length, from the point, leaving the angle of the main shaft only 1° 30′, giving a stronger point and a firmer pin after it is driven.

These pins were made of tool steel, at the United States shops at Lock No. 6, Muscle Shoals Canal. None of them were broken during the season's work. To prevent battering they must be driven by a wooden mallet.

The field books are specially made for this work, which facilitates the work and prevents errors, for there is thus a definite place for recording each quantity.

The notes are kept in ink, using the fountain pen.

On the 20th of April the observations for instrumental values were begun. These must be known before work can be reduced at all.

They are—

(1) Value (n) of one division of level tube in seconds.

(2) The total and relative value of wire intervals for obtaining distance and for inspecting the readings.

(3) The amount of the inequality of telescope rings (p).

(This quantity measures the angle between the line of collimation and the tangent to the level tube at the center point when all adjustments are perfect.)

(4) The value of A of rods, which is the difference between the reading on the level rod and the absolute length of the intercept, or length from bench up to the position of the mean wire.

In rods used together, this A for each should be made equal by filing. For method, see Report of the Chief of Engineers for 1892, p. 2947.

For convenience in computations, the distance (s) at which one division of the tube subtends 1 millimeter is computed.

Tables for each instrument were then made out.

(1) Giving value in millimeters for the movement of bubble through any number of divisions for the length of any ordinary sight.

(2) Giving difference of interval for the same.

(3) Giving distance for any total interval.

(4) For finding correction in millimeters per meter for any error of level tube.

(5) For finding correction in millimeters per meter for error of collimation as shown by any distance from instrument to rod and any difference between readings on rod with telescope, normal and inverted.

(6) Table of limit of discrepancy allowed for all lengths of stretch.

On the morning of the 23d of April, observations for instrumental values having been fixed, actual fieldwork was begun.

METHOD OF WORK.

The method of fieldwork and field computation of notes was very similar to that given in the Report of the Chief of Engineers for 1893, page 3958.

A precise-level party at work requires six men:

One observer, 1 recorder, 2 rodmen, 1 man to handle sun umbrella, 1 man to handle the wind umbrella, who can often be spared to make stakes and cut bench marks.

When there is a great deal of cutting it is profitable to have an additional axman.

Every day, on starting to work, the errors of the instruments were made small by adjustment, but not measured.

The length of sights taken were ordinarily 50 meters which require 16 settings for a mile. When the weather is favorable the sights can profitably be increased to 85 meters, or if unfavorable, from wind or tremulus condition of air, work can be profitably and equally as accurately carried on with 30 meter sights.

With short sights the seeing and estimations are better, the same angular disturbance or error in sighting produces a smaller error in the reading and the compensation of errors has a wider range. These advantages seem to fully offset the greater error that might be expected from the greater number of settings. The progress is slower than with long sights.

Great care was taken to keep the continuous sums of back sights and fore sights running equal, by the recorder keeping a running sum of their differences and sending the forward rodman sufficiently long or short to bring about the result. For the last setting, before the bench, the point to be occupied by the instrument to cause these sums to be equal was closely approximated by reading the distance to each point from a station, estimated to be in the middle and moving accordingly.

The corrections to be applied were consequently quite small.

These corrections arise from three sources:

(1) Error of collimation, from position of the wires.

(2) Error of inclination, from error in the striding level.

(3) Error due to want of equality in the radii of telescope rings.

This last is quite constant, and was observed for only at the beginning and at the end of the season; but observations were made for the measurement of the first two at the close of every day's work.

All were made out, with their proper sign, in millimeters per meter and their sum applied to the excess of sums of sight.

All forward lines, or lines run to a new or additional point, were marked *direct*, and in all of these the back sights are *plus* and foresights *minus* and the sign of the excess tells whether the forward bench is above or below the rear bench and the amount.

All lines run in the opposite direction (or from a new point to a previously determined point) are marked *reverse*, and these back sights are *minus* and the fore sights are *plus*. Then, as in the case of the direct lines, the excess with its sign tells the amount that the forward bench is above or below the rear bench. Thus the forward or unknown point is invariably referred to the back or known point. This system prevents confusion and mistakes.

FIELD COMPUTATION.

As soon as possible, after completing the stretch, before leaving the vicinity, the mean readings and all summations were checked by the rodmen and the difference of elevation, as made by the two runs, carried out by the recorder. If this difference between direct and reverse runs did not vary more than—

$3\text{ mm.}\sqrt{\text{twice the distance between the bench marks in kilometers}}$, the stretch was passed, otherwise the stretch was rerun until a pair of lines answered this condition.

This limit is $3\text{ mm.}\sqrt{\text{distance run in kilometers}}$, for the work is run in a continuous loop from bench A to bench B to bench A again. Whether the return line is practically over the same ground or not makes no difference. The amount that the loop fails to close to zero is the discrepancy between the direct and reverse lines.

FIELD TABULATION.

With the field computation a field tabulation of twenty-one columns was carried along giving book and page and all factors in reference to each stretch. This is indispensable and of use for comparison of office reduction.

PROFILE OF DISCREPANCIES.

A profile of discrepancies of the continuous direct and reverse lines from bench mark to bench mark was also made.

This shows everything in regard to who ran the line, direction, locality, length of stretch, degree of precision obtained, and the sign of the discrepancy, and if there is a constant error at work its presence is soon seen.

CONNECTION WITH OLD WORK.

There were but few old bench marks to be found, and they referred to different datums.

Two elevations were obtained from the Southern Railroad Company and one at the Florence Bridge and one at the Decatur Bridge across the Tennessee River.

I find this elevation at Florence to be 5.060 feet too small and the one at Decatur to be 0.626 foot too large.

The gauge bench and zero gauge at Decatur are, respectively, 7.762 and 7.714 feet too great as given. The stretch of common levels between Riverton and end of line below Pittsburg Landing check generally to within 0.200 of a foot.

BENCH MARKS.

In all there were 61 permanent bench marks set. These were copper bolts leaded into ledges of rock, bowlders, or masonry, either vertically or horizontally, and lettered U S ⊙ P B M Forty-five were set vertically and 16 were set horizontally.

There were also four old permanent bench marks connected with. When following the lines of railroad but few permanent bench marks were left.

There were two established in Burnsville, Miss., one in Iuka, Miss., and one on the river opposite Pride Station, Ala., and two in Tuscumbia, Ala. When following the river a permanent bench mark was established every mile whenever rock could be found. There are, however, several wide gaps along the river where nothing could be found to make permanent bench marks upon. These should be supplied before the temporary bench marks have disappeared. They could be set near these points, requiring but short connecting lines.

Three principal kinds of monuments have been used for bench marks in such places.

First, the stone post, the top and for 6 inches down being squared, and lettered on top $\frac{U\ S}{P\ B\ M}$ ⊙ the point being a copper bolt leaded vertically into the center, and projecting one-eighth of an inch above the surface. This makes a good bench mark, firm, and easy to find, and if well rammed when set, it will settle but little.

P. B. M. 4, that was gotten out at the stone yard at the new lift lock in Riverton, and that we set on the river bank at the lower side of town on May 16, was of this kind. We connected with it again on the 8th of July, and found with certainty that it settled 0.67 millimeters = 0.002 of a foot. The chief objection to it is its weight, about 275 pounds.

The second variety is the stone, 18 by 18 by 4 inches, weighing about 130 pounds, set horizontally 3 feet under the ground, carrying the copper bolt P. B. M. in its center, projecting three-eighths of an inch above the surface, surmounted by a concentric iron pipe 4 inches in diameter, which can be removed and rod held on copper-bolt. This form, as used on the Missouri River, is slightly spread at bottom to hold an iron flange slipped on to it. (See plan and section.) This flange is 10 inches in outer diameter, and anchors the pipe most firmly in place.

The third variety (see section and plan), nsed on the Mississippi River (Report of Chief of Engineers, 1891, p. 3485), is similar to the former, but instead of a stone a *salt-glazed vitrified tile,* with letters cast in, denoting its age and purpose, weighing about 100 pounds, is used. It is surmounted in the same manner by an iron pipe, but instead of the collar being used it is spread at the bottom 1 inch in diameter.

I would respectfully recommend that thirteen additional permanent bench marks, of one of these varieties, be set on this line, as follows:

One at point 2¾ miles below Decatur Bridge, near T. B. M. 171.
One at a point 1½ miles below Finleys Landing, near T. B. M. 164.
One at Foxes Creek, 2 miles above Browns Ferry, near T. B. M. 161.
One at Mallard Creek, 2 miles below Browns Ferry, near T. B. M. 153.
One at a point about 1½ miles above Miltons Bluff, near T. B. M. 146.
One at a point about ½ mile above Boyds Landing, near T. B. M. 206.
One at Pickwick Landing, near T. B. M. 215.
One at North Carolina Landing, near T. B. M. 218.
One a mile below Chambers Creek, near T. B. M. 221.
One at Hamburg Landing, near T. B. M. 225.
One a mile below Lick Creek, near T. B. M. 228.
One just below Snake Creek, near T. B. M. 233.
One about 1¾ miles below Snake Creek, near T. B. M. 237.

There would then be no place more than a mile from a permanent, precise bench mark.

During the season there were 255 temporary bench marks established. Of these 132 were thought to be sufficiently permanent to give in the list of descriptions.

Number of old bench marks connected with..... 24
Number of old gauges connected with..... 6
Elevations of base of rail at depots and crossings..... 10

Two river crossings were made, but it was not necessary in either case to use the process of reciprocal leveling.

At Florence we crossed on the railroad bridge and at Gourd and Weavers Islands by direct observations, one pair of long sights being 274 meters each and another pair 176 meters each.

AMOUNT OF LINE COMPLETED.

Table showing the amount of line and portion that was rerun.

Line.	Meters.	Miles.	1–1,000 parts of whole.	Single line run.
				Miles.
Total distance completed	265,793	165.160	.....	.....
Amount run once	400	.248	1.505	0.248
Amount run twice	245,375	152.473	923.181	304.946
Amount run three times	88	.055	.331	.165
Amount run four times	18,858	11.718	70.950	46.872
Amount run six times	1,072	.666	4.033	3.996
Total miles of single line run	.....	.....	1,000.000	356.227

Thus 7½ per cent of the work did not check on the first bout within the 3 mm. $\sqrt{2\,K}$.

Main line completed.—241.645 km. = 150.155 miles, composed of 259 stretches. Therefore average length of stretch = 933 meters = 3,061 feet.

Side line completed.—24.148 km. = 15.005 miles, composed of 92 stretches. Therefore average length, 262 meters = 810 feet.

Total line completed = 165.16 miles. Miles of line run 356.23.

Number of days in which field work was done, 82, making an average progress for each working day of 2 miles, and of 4.34 miles of single line run.

During the last half of July it rained hard every day, making work and traveling difficult. The stretch below Riverton was particularly troublesome, for the country is but sparsely settled and no accommodations could be found save back among the hills from 2 to 3 miles from the river. There were no roads or paths along the river, but all was grown up with weeds, corn, brush, or cane. There are six pretty large creeks and many small ones to cross on this stretch, and frequently it happened that skiffs for crossing and recrossing these were not easily obtained.

The best season to do precise leveling on the lower Tennessee is from the middle of February to the middle of June; then the leaves are not so much in the way, the wild growth is down, and, most important of all, the cornfields, which cover a very large percentage of the area, at this season do not present such an obstacle to progress.

Total number of lines run, 767; of these 24 pairs did not check within the limit.

The greatest discrepancy in any of these was one of 14.2 mm., two of 6, six of 5, and seven of 4.

One loop showed a discrepancy of 100 mm., but this error was subsequently located in the field on the first setting at the bench. All three wires were read, at least recorded, 100 mm. wrong, but there were two more lines run over this stretch.

The summation of residuals and field plot of discrepancies show that we were quite successful in keeping out errors of a constant nature. The independent, direct, and reverse lines crossed the mean line several times; the errors were as likely to be plus as minus.

Assistant F. B. Williams and Recorders N. E. Ferguson and W. H. Henby gave efficient and faithful service to the work.

OFFICE REDUCTION.

In this work I have been assisted by Mr. Edgar C. Thompson.

First, the notebooks were indexed.

Then the observations for instrumental factors, both at the beginning and end of the season, were recomputed.

The first values were used for the first half of the season and the last values for the last half of the season, excepting *inequality of telescope rings*, which showed so much change that for the middle one-third of the season means of the first and last were used.

From these values tables were made for recomputing the results for each instrument:

(1) Table giving the length of an observation for any total interval.

(2) Table giving length of stretch from mean length of sight and summation of total intervals.

(3) Table to find correction for inclination.

(4) Table to find correction for collimation.

(5) Table to convert meters to feet.

All observations for corrections due to the errors of collimation and inclination were recomputed, and a list of corrections made out giving the total correction in millimeters per meter for collimation, inclination, and rings for each day.

STANDARD LENGTH OF 1 METER ON RODS USED.

The rods used were Nos. X, XIII, XV, and XVI.

In the report for 1893, page 3960, the standard lengths of a meter on Rods X and XIII are given, but there are no comparisons for Rods XV and XVI since 1882.

By the aid of magnifying glass and scale divided to one-sixtieth inch and reversals to eliminate parallax all were compared with Rod X.

Rod XIII was shorter than Rod X = 0.150 mm. and for 1 m. shorter by 0.050 mm.

This agrees pretty well with 1893, where 1 m. of XIII is shorter than X by 0.038 mm.

We took for 1 meter of Rod X the same as found in 1893, 1,000,222 mm.

Comparisons further showed 1 m. of Rod XV to be 0.088 mm. shorter than 1 m. of X and 1 m. of Rod XVI to be 0.021 mm. shorter than 1 m. of X.

Therefore we have—

1 m. of Rod X = 1,000,222
1 m. of Rod XIII = 1,000,172
1 m. of Rod XV = 1,000,134
1 m. of Rod XVI = 1,000,012

Value of 1 meter used = mean = 1,000,135 standard.

The "rod correction," therefore, will have the effect of increasing all differences of elevation.

Following is a résumé of all instrumental values:

RECAPITULATION OF INSTRUMENTAL VALUES.

Value of one division of level tube in seconds of angle = n.

Number of tube.	Date of observation.	*n* in seconds.	Subtends 1 mm. at S.	Used by—
			Meters.	
9	Apr. 22	3.384	60.95	O. W. F.
5	....do ...	1.742	118.41	F. B. W.
9	Aug. 1	2.226	92.83	O. W. F.
5	....do ...	2.567	80.35	F. B. W.

Inequality of telescope rings = p.

Number of telescope.	Date of observation.	Value of *p*.	Correction per m.	Used by—
		Seconds.	*Millimeter.*	
2	Apr. 20	2.338	+0.011	O. W. F.
3	....do ...	0.211	—0.001	F. B. W.
2	Aug. 1	1.658	—0.008	O. W. F.
3	....do ...	5.303	—0.026	F. B. W.

Angular value of wire interval.

Number of telescope.	Date of observation.	First interval.	Second interval.	Total interval.	Spreads per m beyond (*c*+*f*).	Used by—
		′ ″	′ ″	′ ″	*Millimeter.*	
2	Apr. 22	7 6.40	7 44.82	14 51.21	4.3225	O. W. F.
3	....do ...	8 34.52	9 00.33	17 34.85	5.1083	F. B. W.
2	Aug. 1	7 6.17	7 42.54	14 48.70	4.3052	O. W. F.
3	....do ...	8 34.48	9 1.90	17 36.37	5.1188	F. W. B.

c+*f* = 0.55 m.

Value of A of Rods X, XIII, XV, and XVI.

Number of rod.	Date of observation.	Reading on rod.	Reading on ruler.	A of rod.	Used by—
		Millimeters.	*Millimeters.*	*Millimeters.*	
X	Apr. 26, 1895	150.21	95.00	—55.21	F. B. W.
XIII	.....do	148.21	93.10	—55.11	F. W. B.
XV	.....do	149.19	93.09	—56.10	O. W. F.
XVI	.....do	149.22	93.09	—56.13	O. W. B.

Being the means of six observations.

Standard length of 1 meter on the rods used.

Standard length of 1 m. of—		
Rod X (Report for 1893, p. 3960)	millimeters..	1,000.222
Rod XIII, 0.052 millimeter shorter than X	do....	1,000.170
Rod XV, 0.088 millimeter shorter than X	do....	1,000.134
Rod XVI, 0.210 millimeter shorter than X	do....	1,000.012
Therefore, mean length of m. used	do....	1,000.135
Value of meter	feet....	3.2808693

N = number of seconds of curvature in one division of tube.
S = the distance where the tangent of one division of tube becomes 1 mm.
p = one-half of the angle of the cone enveloping the telescope rings.
A = the correction to a rod reading to make it refer to the point held on.
$(c+f)$ = the distance from center of instrument to the point in front of object glass where the rays diverge.

All quantities in the 28 field books were checked, the sum of mean wires for each page being derived in an entirely different manner from that of the field computation.

The errors found in the field books were:

Fourteen cases where one of the three wires was recorded 100 mm. wrong.

Sixteen cases where an error of 1 mm. was made in taking out mean wire.

Ten cases where an error of 0.3 mm. was made in taking out mean wire.

One case where A of rod had been omitted.

One case where A of rod had been applied with wrong sign.

Two cases where the difference of elevation between bench marks had been given the wrong sign.

All quantities in the notebooks being checked a new computation and closure of each run was made by transcribing observations on computation sheets.

Each run, as it was closed, was compared with the field result and all variations accounted for.

A new tabulation was then made of these results and quantities carried out independent of the field tabulation. Comparison of these two showed ten considerable errors in the latter, seven in carrying out the elevations and three in using the wrong sign in carrying out the difference of elevation. There were also two errors where direct and reverse lines were interchanged.

Only six single runs between benches were rejected. They were rejected because their accuracy was suspected and because they varied widely from other lines.

In this computation the greatest divergence of the direct and reverse lines was at Tuscumbia, (— and + 18.2 mm.) = 36.4 mm.

If it were due to a constant error, it showed settling, but it entirely disappeared in the next 35 miles, and if this were due to a constant instead of to accidental errors, it showed heaving. At Decatur these lines were but — and + 1.1 mm., or 2.2 mm., apart, and at the end of season + and — 3.1 mm., or 6.2 mm., apart.

CONNECTING WITH MEAN GULF LEVEL.

In the polygon of precise levels, Biloxi, Mobile, Corinth, Memphis, Greenville, New Orleans, Biloxi, the portions Biloxi, Mobile, Corinth, Memphis, and from Greenville to New Orleans was executed by the United States Coast and Geodetic Survey.

The portion Memphis to Friars Point in 1877–1879 by the United States Lake Survey, and from Friars Point to Greenville in 1880–81 by the Mississippi River Commission.

The line New Orleans to Biloxi, 87 miles, was done by the Mississippi River Commission in 1882 and by the United States Coast and Geodetic Survey in 1886.

In this loop of 1,140 miles only 45 miles of the line, from Prentiss to Greenville, was done in a manner to perfectly eliminate personal and constant errors, and in much of the polygon, the lines being run parallel, there was no elimination of these errors.

On the line from New Orleans to Biloxi, as done by the Mississippi River Commission, one instrument ran all of the east line and the other ran all of the west line. This is a great deal better than running both lines in the same direction, but the only correct method is for the same instrument and party to run the direct and reverse line as a continuous loop from bench mark to bench mark.

The elevation of mean Gulf level is not yet well determined. The self-registering gauge is at Biloxi, Miss. The Mississippi River Commission obtained a preliminary reading of 6.456 feet for mean Gulf level on this gauge by taking the mean of readings from June to September, 1882. (See Report of Chief of Engineers for 1894, p. 2795.)

The United States Coast and Geodetic Survey also obtained a reading on this gauge for mean Gulf level by taking the mean of readings from September 7, 1881, to November 24, 1882, of 6.23 feet, making mean Gulf 0.226 feet lower than did the Mississippi River Commission.

The United States Coast Survey in carrying elevations between New Orleans and Biloxi bench marks, make a difference of elevation of 0.186 feet more than the Mississippi River Commission, New Orleans being the higher end, and as their sea level is 0.226 feet lower, their elevations above sea level in New Orleans is 0.186+0.226= 0.412 feet greater than Mississippi River Commission.

We find the elevation of permanent bench mark Memphis, which is a horizontal copper bolt in the west side of court-house, above Mississippi River Commission preliminary mean Gulf level by the New Orleans and Greenville line as follows:

(1) Gulf level above Cairo datum (see Report of Chief of Engineers, for 1884, p. 2476):

	Feet.
8-foot mark of tide gauge above Cairo datum, 9.6501 meters	22.802
Preliminary mean reading for Mississippi River Commission on same gauge, 6.456 feet, which is 1.544 feet lower than the 8-foot mark	1.544
(1) Gulf level above Cairo datum	21.258
(2) P. B. M. Memphis above Cairo datum (Report Mississippi River Commission, 1881, p. 63 Appendix C, printed in Senate Ex. Doc. No. 10, Forty-seventh Congress, first session), 86.6783 meters	284.3802
(3) Therefore P. B. M. Memphis above Mississippi River Commission mean Gulf	263.122
(4) P. B. M. Memphis above Memphis datum (Report of Chief of Engineers for 1878, p. 1394), 82.6762 meters	271.250
(5) Therefore (2–4) Memphis datum above Cairo datum	13.130
(6) Therefore (1–5) Gulf level above Memphis datum	8.128
(7) The elevation of P. B. M. Memphis, if determined by the United States Coast and Geodetic Survey by way of New Orleans and Greenville, would be 0.412 higher than the above (3) or	263.534
(8) The elevation of P. B. M. Memphis as determined by United States Coast and Geodetic Survey by way of Mobile, Corinth (Report for 1892, Part II, p. 219), 80.0460 meters	262.620

or 0.502 feet lower than the above (3).

(9) Referring (7) to Mississippi River Commission preliminary mean Gulf level, the same as (3) Mississippi River Commission being 0.226 feet higher, we have	263.308
(10) Referring (8) to Mississippi River Commission mean Gulf in the same way, we have	262.394

(9) is greater than (3) 0.186 feet.

(10) is less than (3) 0.728 feet. Error of closure of loop, 0.914±.

For Gulf level elevation at Corinth we probably can not do better than to take (3) elevation of P. B. M. Memphis above Mississippi River Commission preliminary Gulf level, as determined by their line of precise levels from Biloxi to New Orleans, the United States Coast and Geodetic Survey levels thence to Greenville, and the U. S. E. levels thence to P. B. M. Memphis, and lastly applying to this the difference of elevation between P. B. M. Memphis and V and W at Corinth.

This will also be in accord with elevations on the Mississippi River, though their datum for precise levels is Cairo datum.

In the Report of the United States Coast and Geodetic Survey for 1892, Part II, pages 218, 207, and 169, we have the elevations of P. B. M. Memphis = 80.0460 meters.

B. M. V = 137.2281 meters
B. M. W = 137.2849 meters

Mean = 137.2565 meters = 450.321 feet.

Mean of V and W above P. B. M. Memphis = 57.2105 meters. From (3) elevation P. B. M. Memphis, 263.122 = 80.1988 meters. Therefore, 137.4093 meters = the mean elevation of V and W at Corinth, Miss., above the Mississippi River Commission preliminary Gulf level. From this we start our tabulation for Tennessee River precise levels.

It is thought that the final elevation of mean Gulf will vary from the preliminary $\pm$0.2 of a foot.

The United States Coast and Geodetic Survey (Report for 1892, Part II, p. 192) contemplates running a check line from Meridian, Miss., to Vicksburg and subsequently adjusting the loops for final elevation.

All this season's work is completed in stretches of about 1 km. from bench mark to bench mark. The limit of error of closing these loops of whatever length was 3 mm. $\sqrt{2}$ km., or in feet and miles (M.) 0.01248 feet $\sqrt{2}$ M.

This formula can only apply to the work stretch by stretch, and properly so, for its purpose is to secure equally good work over all parts of the line.

Thus for a stretch one-half mile long the limit is $\pm$ 3.8 mm. and if the loop checked to 2.8 mm. the work would pass as good.

The next stretch, also of a half mile, may also check to 2.8 mm. of the same sign as the first, and be equally good. Though the whole mile checks to 5.6 mm. (5.4 mm. being limit for a mile), we know that the error is distributed and the work is all good.

If the whole mile had been run as one stretch it would have to be rerun, because there would be doubt as to how the discrepancy of 5.6 mm. had risen.

If there is a constant error resulting from any cause, though it be quite small and frequently overcome by the accidental errors happening to have the opposite sign, it will soon carry the divergence of the continuous direct and reverse lines beyond this limit.

A constant error hurts the appearance of the work, but we eliminate it in the mean of direct and reverse lines.

Even if there is no constant error, the continuous direct and reverse lines may separate from 15 to 40 mm. through the accidental errors, but if so, they are then full as likely to take a turn the other way and greatly reduce this during the next equal distance.

This is the way it has resulted during the work of this and previous seasons, the two lines crossing several times. In any considerable distances the divergence of the two continuous lines stay within the 3 mm. $\sqrt{2k}$. Because the mean of the two lines which is used eliminates constants and partially eliminates all other errors, on closing a polygon of precise level of any length much more might be expected that the error of closure would be within the limit prescribed for each part of it. So far the polygons that have been closed partially fulfill this expectation.

The best showing is apparently the polygon Chicago, Savanna, Ill.; New Orleans, Sandy Hook, Albany, Chicago, of about 4,000 miles perimeter, obtained partly by water levels and partly by spirit levels, closing to 1 foot, which is 0.11 foot inside of 3 mm. $\sqrt{2k}$.

The polygon Duluth, St. Paul, Savanna, Ill.; Chicago, Duluth, of about 1,100 miles, partly by water and partly by spirit levels, closed to about 5 inches, which is 0.12 foot inside the 3 mm. $\sqrt{2k}$.

When this line is carried down the Tennessee River to Paducah and Cairo, the polygon Cairo, Memphis, Corinth, Cairo will be closed over a different route, in part, from the closure of it made by the United States Coast and Geodetic Survey.

In running a loop between two adjacent bench marks, the closure should be zero. The amount it fails to do this indicates the degree of precision to be looked for on other stretches, and is made up (1) of the amount of accumulation of any constant error which is the resulting sum of all constant errors; (2) of the resulting sum of all accidental errors which arise from unstable instrument settings or rod supports, of errors due to loose and changing collimations or inclination, of errors in recording, and, lastly, of errors or blunders in judgment or manipulation by observer in taking the readings. Any of these errors may be large, small, or zero, and the closure be in any case poor or good.

These errors are all doing business in partnership and can not be segregated in the first pair of lines run, for they may combine unfavorably or favorably.

By watching their sign, amount, continuity or want of continuity in connection with conditions of ground and weather, and by making such alterations that they can not occur again where they are suspected to arise, they can be traced to their sources and all reduced to a harmoniously small magnitude.

The profile of discrepancies shows the rate of increase and sign of these discrepancies.

A most essential requirement in precise leveling is good rodmen. It is of more importance that they have good common sense, obedience, carefulness, promptness, and patience than that they be educated men. If rodmen assent to orders, but hold them of small importance, safe conclusions in the above study can not be arrived at.

The field of the precise leveler is scientific—to know the nature and relation of conditions and things, to obtain the proper tools, and to devise the true remedy for any defects in tools or methods. It is artistic—to properly apply the above remedies, to manipulate the instrument, and get the reading. The best work over a loop, to give good eliminations, should proceed regularly in respect to time. It is executive to put the right man in the right place and then to discover his defects. There is a great deal of sameness, but good results obtained on one stretch do not help the next. Constant effort is required, and caution is to be given only with discretion. Care of all the party will not overcome a defect in one. This feature is troublesome in precise work, there being but little of it in ordinary surveying where the criterion is "a tenth is nothing and a yard is as near as it will plat."

Some poor work at times seems necessary as an educational feature to prevent carelessness.

THE DISTINGUISHING FEATURES OF THE PRECISE LEVELING SYSTEM.

Lines of levels, when in error, are made so by one or more of four causes:

(1) Errors in the instruments.
(2) Erroneous or inaccurate reading.
(3) Change in elevation of instrument or rods during observations.
(4) Blunders or errors in reading or in connections.

Our system takes special consideration of all of these sources of error and reduces them to a minimum.

1. The instruments are of the best quality and regular attention is paid to their adjustment. The errors at the end of each day's work are measured and recorded, and these errors, whether small or large, are quite perfectly eliminated by the nearly perfect equality of sights.

2. The instrument is protected from sun and wind. The rods are held plumb and steady by the watch level. There is no movement of persons around the instrument when reading. The back sight and corresponding fore sight are taken with bearings and bubble the same.

3. The heaving or setting of instruments and rods (which may aggregate a foot in 100 miles) and all constant errors and the greater portion of accidental errors are eliminated by taking the mean difference of elevation of the direct and reverse lines for the true difference.

4. Blunders or errors made in reading or recording are excluded, for they destroy the relation existing between the intervals of the three wires read. The system of points is simple, the only object being to find the difference of elevation between the two points at ends of the stretch, the intervening points being destroyed. We have also the duplicate line to rely upon for comparison to detect such errors. The system is perfect, and if executed intelligently will not only be free from large errors but give most accurate results.

No system can prevent the defects of carelessness. There is some danger in confusion of points. The system of points should be kept simple and well understood between the observer and the recorder, and the duplication of work must be complete. If the recorder gets a little behind and is in a little doubt about what the decimeters were, and if he does not inquire, he may get all three wires down a decimeter wrong, and if the same errors were made in the reverse line it could not be detected in the notes.

In continuing a line from a stake in another line there might be two stakes and the wrong one used.

In making a point for a temporary benchmark and abandoning it because of its being behind some object, unless the first point is demolished it may still be used to continue the line from.

Starting in several places on a ledge of rock and abandoning one after another because the rock appears unsound could in the same way lead a line into errors.

When these blunders occur it is from being intent on the finer features of the work and from not appreciating the possibility of their arising.

Very respectfully submitted.

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Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

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DESCRIPTION AND ELEVATION OF PRECISE-LEVEL BENCH MARKS FROM CORINTH, MISS., TO DECATUR, ALA., BY THE WAY OF RIVERTON JUNCTION, TUSCUMBIA, FLORENCE, AND THE MUSCLE SHOALS CANAL. ALSO FROM RIVERTON JUNCTION TO RIVERTON, AND DOWN THE TENNESSEE RIVER TO FOUR MILES BELOW PITTSBURG LANDING.

All elevations are given in meters and feet and refer to "preliminary mean Gulf level," as derived by the Mississippi River Commission and carried to Corinth by the way of New Orleans and Memphis by the Commission and the United States Coast and Geodetic Survey.

To reduce these elevations to Cairo datum add 21.258 feet; to reduce these elevations to Memphis datum add 8.128 feet.

A P. B. M. is a precise-level bench mark so established as to be practically permanent.

A T. B. M. is a precise-level bench mark of not quite so permanent a nature as a P. B. M.

All P. B. M.'s (excepting No. 5, which is top of a stone post) are copper bolts leaded into stone monuments or masonry and lettered $\begin{matrix} U & S \\ & o \\ P & B & M \end{matrix}$ cut into the stone. Letters are $1\frac{3}{4}$ inches high and three-sixteenths of an inch deep.

When set vertically the top of the bolt stands about 0.003 foot above the surface of stone, and when set horizontally the end of the bolt was about three-sixteenths of an inch back of the surface of the masonry, and the mark used is center of "prick punch" in center of bolt T.

The T. B. M.'s are spikes driven to their heads into roots of trees or timber work, or the highest points of rounded knobs, cut on stones and surrounded by squares cut into stone of $1\frac{1}{2}$ inches on a side and three-eighths of an inch deep, and lettered "U. S." whenever there was sufficient room. When on trees the spike is driven into a shoulder cut on base, and the tree is blazed directly over the bench, about 4 feet above the ground.

Only such bench marks are described as it is thought will last for five years at least.

O. W. FERGUSON,
Assistant Engineer.

Description and elevation of precise-level bench marks between Corinth and Decatur.

Number.	Description.	Elevation.	
		Meters.	Feet.
U. S. C. and G. S. B. M. "V." Corinth, Miss.	At Corinth, Alcorn County, Miss. On the west side of Waldren street, opposite the court-house, in the east wall of brick building used as the city hall, near the north end of the building, in fourth brick south of window and in third course above the window sill, being center of cross cut in a brass bolt leaded horizontally.	137.3805	450.727
U. S. C. and G. S. B. M. "W."	Is in Corinth, Miss., on Waldren street, in the west wall of court-house, in the fifth brick south of the fifth cellar ventilator, counting from the northwest corner of the building, and in the fourteenth row of brick below the line of window sills, being center of cross cut in a brass bolt leaded horizontally.	137.4377	450.915
T. B. M. 1	Is in Corinth, Miss., in the southwestern part of court-house yard, on curbing of well at its northeast corner, being the highest point in square, cut in stone and marked "U. S."	136.9606	449.350
T. B. M. 5. Water tank.	Is on the line of the Memphis and Charleston Railroad, about 2 miles east of Corinth, Miss., in the southeast corner of wooden foundation of water tank, being top of spike.	134.1098	439.997
T. B. M. 8	Is ½ mile east of Homeolucky Creek, 3 feet west of the third telegraph pole east of mile post 97 from Memphis, about 18 feet north from track center, in cedar stump, being top of spike.	152.6596	500.856
T. B. M. 9	Is about ¼ mile west of mile post 98 from Memphis, 4½ miles east of Corinth, Miss., about 26 feet south of track center, on small rise of ground, with lower ground each side and much higher ground on opposite side of track, on a small red oak tree, blazed facing the track, being top of spike in root.	152.8132	501.360
T. B. M. 13. Glens.	Is about 700 feet west of Glens, 18 feet north of track, and 3 feet east of the second telegraph pole west of mile post 101, being top of spike in cedar post.	149.8541	491.658
T. B. M. 15	Is about 1¼ miles east of Glens, 1,400 feet east of mile post 102 from Memphis, 20 feet north of track center, in cedar stump, being top of spike.	143.8063	471.810
T. B. M. 19	Is 3 miles west of Burnsville, Miss., ½ mile west of mile post 105, 280 feet east of stone bridge and 28 feet south of center of track, on a new pine stump 22 inches in diameter and 2½ feet high, being top of spike.	149.2774	489.760
T. B. M. 23	Is in Burnsville, Miss., 120 feet west of center of depot and 95 feet north of track center, on a high ridge of ground, on the prominent sycamore tree 2 feet in diameter, on north root, 2 inches above ground; being top of a 20d cut spike.	142.2485	466.699
P. B. M., 1. Burnsville, Miss.	Is in Burnsville, Miss., 195 feet south of station, in west wall of brick house belonging to Mr. M. O. Elledge, 105 feet south of its northwest corner, in the fifteenth course of brick from the ground; being center of punch mark in copper bolt leaded horizontally.	143.0301	469.263
P. B. M. 2	Is in Burnsville, Miss., 138 feet north of center of railroad track, 65 feet east of the east end of depot, in foundation of old turntable, on the east part of wall near center of large coping stone; being top of copper bolt leaded vertically.	141.5677	464.465
T. B. M. 25. Yellow Creek.	Is 1 mile east of Burnsville, Miss., 495 feet east of long trestle over Yellow Creek, 18 feet north of track center, in stump of cedar telegraph pole; being top of spike.	135.3491	444.063
T. B. M. 28	Is 3 miles west of Iuka, 1,340 feet east of milepost 112 from Memphis, 20 feet north from center of track, at east end of fill, in stump of cedar telegraph pole; being top of spike.	159.1869	522.271
T. B. M. 31	Is 1¼ miles west of Iuka, on north side of track, 52 feet east of milepost 114, in stump of cedar telegraph pole; being top of spike.	178.7636	586.500
P. B. M. 3. Iuka.	Is 2,250 feet west of depot at Iuka and 1,190 feet west of milepost 115, in south end of stone culvert, in top stone 5¾ inches from south edge and 37¾ inches from west edge; being top of a copper bolt leaded vertically.	170.9300	560.799
T. B. M. 36	Is 2 miles west of Iuka, 1,475 feet east of milepost 117, 1,085 feet west of water tank, 48 feet south of center of track, in root of white oak tree; being top of spike.	167.6953	550.186
T. B. M. 39. Gravel Siding.	Is ½ mile east of Gravel Siding, 95 feet east of milepost 119, 48 feet north of center of track, in root of hickory tree; being top of spike.	141.9458	465.706
T. B. M. 41. Pegram.	Is about a mile west of Pegram and ½ mile east of milepost 120, on the west abutment of bridge at its northwest corner, on coping stone; being highest point in square cut in stone.	130.8366	429.258
T. B. M. 43. Big Bear River.	Is about ¾ of a mile west of Riverton Junction at bridge over Big Bear River, on east abutment, north side; being highest point in square cut in stone.	124.8848	409.731
T. B. M. 45. Margerum.	Is at Margerum, on footing course of masonry, at the southwest corner of water tank, at north edge of track; being the highest point in square.	131.9177	432.805
T. B. M. 47	Is 1¼ miles east of Margerum, 410 feet west of milepost 125 (from Memphis), on west abutment of railroad bridge over Buzzard Roost Creek, at its southeast corner; being highest point of square cut in stone.	133.5308	438.097

Description and elevation of precise-level bench marks, etc.—Continued.

Number.	Description.	Elevation.	
		Meters.	Feet.
T. B. M. 49	Is 2¼ miles west of Cherokee, 2,190 feet west of milepost 127, on big fill, 10 feet south of center of track, 3 feet below top of tie, on a large embedded rock; being the highest point in a square.	147.5719	484.164
T. B. M. 52 Cherokee.	Is in Cherokee, Ala., 185 feet west of center of depot, and 70 feet south of center of track; being top of spike in root of black gum tree.	157.8708	517.953
T. B. M. 55	Is 2 miles east of Cherokee, 870 feet west of milepost 131, about 60 feet north from center of track; being top of spike in root of an oak tree.	153.9698	505.155
T. B. M. 56	Is 2½ miles east of Cherokee, 1,780 feet east of milepost 131, about 70 feet north of center of track; being spike in root of a white oak tree.	149.2516	489.675
T. B. M. 58	Is ¾ of a mile west of Barton depot, 1,390 feet east of milepost 133. 15 feet south of center of track, on the end of stone culvert; being the highest point in square.	149.7938	491.454
T. B. M. 59 Barton.	Is 354 feet west of Barton depot, 15 feet north of track center, on an embedded rock; being the highest point in square.	145.8450	478.498
T. B. M. 63 Bear River.	Is 1½ miles west of Prides, 1,720 feet east of milepost 136, on south end of abutment of bridge over Bear River, on coping 3 feet below top of ties; being highest point of square cut in stone.	130.0290	426.608
T. B. M. 72	Is at Prides, 2,130 feet toward the river from Prides Station, about 450 feet west from L. T. Pride's house, 30 feet east of a large mulberry tree, on east edge of creek bed, on a large ledge of rock washed by its water; being highest point in square marked U. S.	129.6293	425.297
P. B. M. 7	Is at Prides, Ala., 160 feet above mouth of creek that empties just above J. P. Pride's residence, 27 feet back from top edge of high bank on point of bluff, at cluster of bowlders on the north face of a large embedded bowlder, 14 inches above surface of ground; being a copper bolt leaded horizontally.	127.5518	418.481
T. B. M. 73	Is 20 feet northeast of P. B. M. 7, on a very large bowlder; being highest point of square cut in the rock and lettered T. B. M. by deeply cut letters.	126.5102	415.063
T. B. M. 68	Is 2¾ miles east of Prides depot, 460 feet east of milepost 140, in big cut, about 25 feet east of the east end of long tangent through Cherokee and Prides, 15 feet south of center of track and 1½ feet above top of tie; being highest point in square cut in ledge.	147.5322	484.034
T. B. M. 71	Is 4 miles east of Prides, at west end of railroad bridge over Little Bear Creek, on west end of abutment, 460 feet west of milepost 142; being highest point in square cut on stone.	136.7884	448.785
T. B. M. 79	Is in west edge of Tuscumbia at east end of railroad bridge over Spring Creek, on the north end of coping stone of abutment, 3 feet below top of ties; being the highest point in square.	136.0033	446.209
T. B. M. 80	Is in Tuscumbia, Ala., on end of a curbstone at the northwest end of the Parshal Hotel; being highest point in square.	141.5319	464.348
P. B. M. 8	Is in Tuscumbia, Ala., in the southwest corner of the county court-house in water table 6½ inches east of corner; being center punch mark of copper bolt leaded horizontally.	145.1156	476.105
P. B. M. 9 Tuscumbia, Ala.	Is in Tuscumbia, Ala., on the east side of Main street 16½ feet south from Fifth street, on the stone base of Mr. Wilson's bank building; being a copper bolt leaded vertically.	141.9452	465.704
T. B. M. 83	Is on line of railroad between Tuscumbia and Florence, 25 feet west from center of track, 730 feet south of the intersection of this branch of the Memphis and Charleston with the Birmingham, Sheffield and Tennessee River Railroad; being spike in stump of a telegraph pole.	155.5067	510.197
T. B. M. 86	Is opposite Florence, Ala., on east end of south abutment of Memphis and Charleston Railroad bridge over Tennessee River at about the elevation of top of ties; being highest point in square cut in coping.	140.0936	459.629
P. B. M. 10 Tennessee River.	Is on south side of the Tennessee River, opposite Florence, Ala., on lower or wagon-way abutment of the Memphis and Charleston Railroad bridge, in east end of bridge seat stone, 5 inches from its east end and 4½ inches back from its front face; being top of copper bolt leaded vertically.	133.3095	437.371
T. B. M. 87	Is at Florence, Ala., on the north end of railroad bridge over the Tennessee River, on east end of stone abutment, about the elevation of top of ties; being the highest point in square marked U. S.	136.0744	446.442
Old gauge B. M.	Is at the north end of bridge across the Tennessee River at Florence, Ala., on the second pier north of wagon road, on the west side of bent, on pedestal stone, 7 inches from its west edge and 6 inches from its north edge; being highest point of square in the southwest part of cross marked U. + S. B. M.	130.1444	426.987

Description and elevation of precise-level bench marks, etc.—Continued.

Number.	Description.	Elevation.	
		Meters.	Feet.
Gauge (zero of)....	At Florence is a staff gauge on the northwest quarter of draw pier.	120.9332	396.766
P.B.M.11.....	Is at Florence, Ala., upon the draw pier of the Memphis and Charleston Railroad Bridge across the Tennessee River, 9 feet north of the pivot, 28 inches above the up-river side of the span when closed and 6 inches outside of rack; being a copper belt leaded vertically.	130.3552	427.678
P.B.M.12..... Florence.	Is at Florence, on the north side of the Tennessee River, the second pier north of the north abutment of Florence Bridge, on east pedestal stone, near its northwest corner; being top of copper bolt leaded vertically	130.4552	428.007
T.B.M.90.....	Is at Florence, on line of Louisville and Nashville Railroad on right bank of river, about 300 feet below the northwest corner of lock factory, 16 feet south of track center, and $\frac{1}{2}$ foot above top of ties; being highest point in square cut in ledge of rock.	138.6103	454.762
P.B.M.13.....	Is in Florence, Ala., in the Louisville and Nashville Railroad yards, 374 feet below the northwest corner of lock factory, and 203 feet east of a small trestle, 39 feet from top of high river bank 12 feet north of the center of south track, and 2 feet above top of ties, in a very large blue limestone; being center of punch mark of copper bolt leaded horizontally and marked U.S.P.B.M.; also an arrow is cut upon the stone pointing to the bolt.	138.0105	452.794
P.B.M.14..... East Florence.	Is in East Florence, in old bucket factory, now occupied by the Eureka Lumber Company, on the inside face of north wall in the first pier east of the first arch about 4 feet above the ground, in center stone; being copper bolt leaded horizontally.	142.8044	468.523
T.B.M.93.....	Is $1\frac{1}{4}$ miles above East Florence at foot of hill opposite the end of old railroad, 32 feet east of ravine and 115 feet north of river bank, on ledge of rock in place; being highest point in square.	132.1709	433.635
P.B.M.15.....	Is about $1\frac{1}{4}$ miles above East Florence, 215 feet east of ravine, at end of abandoned railroad, about 183 feet above T.B.M. 93, about 650 feet east from dam on opposite side of river, in vertical ledge of rock; being copper bolt leaded horizontally.	133.7848	438.931
T.B.M.94.....	Is about 2,135 feet above the end of old abandoned railroad, and 65 feet from foot of bluff, on south root of a large blazed elm tree; being top of large spike.	128.2457	420.757
T.B.M.95.....	Is 2 miles above East Florence, 1,440 feet below the large falling spring called Dunnehue's Spring, on sycamore tree 20 feet back from river at ordinary stage; being spike in the root.	126.8778	416.270
P.B.M.16.....	Is about $2\frac{1}{4}$ miles above East Florence and $\frac{1}{4}$ mile below mouth of Four Mile Creek, 28 feet west of the Dunnehue Falling Spring and about 9 feet in elevation above the path, under overhanging rock, inside of a wall where there had been a camp; being copper bolt leaded horizontally.	132.1871	433.689
P.B.M.17.....	Is $1\frac{1}{4}$ miles below Bainbridge, 1,870 feet below lower end of field, a short distance below the very large rock in river about 20 feet from shore, in a large rectangular bowlder sloping toward the river and forming retaining wall for path, 10 feet toward river from path, about 2 feet from river edge of bowlder and 1 foot from upstream edge; being copper bolt leaded vertically.	129.4745	424.789
T.B.M.99.....	Is 1 mile below Bainbridge, about 190 feet below lower end of field and 50 feet below wire fence running to river, and 75 feet from river shore, on a large rock blown down from bluff; being the highest point in square.	130.0753	426.760
T.B.M.100..... Bainbridge.	Is at Bainbridge, in front of Mr. Bud Morrison's house, 10 feet from shore of river, on low ground, where point of brush and vines jut into cornfield, on a large water oak; being spike in root.	129.8265	425.944
P.B.M.18.....	Is at Bainbridge, 1,160 feet west of the west end of lock 9, Muscle Shoals Canal, 18 feet north of Morrison's spring, 4 feet west of small blacksmith shop, 37 feet north of center of the present wagon road and $5\frac{1}{2}$ feet above it, under overhanging rock; being a copper bolt leaded horizontally.	132.7152	435.421
T.B.M.102..... Lock 9.	Is at lock 9, Muscle Shoals Canal, on north side and west end; being highest point in square, cut in top of masonry.	131.7418	432.228
P.B.M.19.....	Is at lock 9, Muscle Shoals Canal, on the river side of lock, at west heel post, between the A straps, 7 inches from iron shoe; being copper bolt leaded vertically.	131.7479	432.248
T.B.M.103..... Lock 8.	Is on south side of lock No. 8, Muscle Shoals Canal, at its foot on south side of masonry; being highest point in square marked U.S. T.B.M.	134.8139	442.307

Description and elevation of precise-level bench-marks, etc.—Continued.

Number.	Description.	Elevation.	
		Meters.	Feet.
P. B. M. 20	Is at lock No. 8, Muscle Shoals Canal, on the river side of lock, at the west heel post, between the A straps, 6 inches from the iron shoe; being copper bolt leaded vertically.	134.8193	442.325
T. B. M. 104	Is at lock No. 7, of Muscle Shoals Canal, on south side and west end of lock, near the southwest corner of stone forming third step from top; being highest point in square.	137.3976	450.783
P. B. M. 21 Lock 7.	Is on river side of lock No. 7, Muscle Shoals Canal, at west heel post, between the A straps, about 6 inches from the iron shoe; being top of copper bolt leaded vertically.	138.4641	454.283
P. B. M. 22 Shoal Creek.	Is on the south end of east abutment of railroad bridge over Shoal Creek, Muscle Shoals Canal, 1,445 feet east from foot of lock 7, 1 foot from west edge and 15 inches from south edge of stone; being top of copper bolt leaded vertically.	138.3128	453.786
T. B. M. 105	Is ½ mile east from lock 7, Muscle Shoals Canal, 150 feet west of section posts 26 and 27, on large rock, about 12 feet south of center of track; being highest point in square cut in stone.	138.7027	455.066
T. B. M. 107 Lock 6.	Is at lock No. 6, Muscle Shoals Canal, south side west end, on fourth step below coping; being highest point in square cut on stone.	141.2036	463.271
P. B. M. 23	Is at lock No. 6, Muscle Shoals Canal, on river side, at west heel post, between the A straps, about 6 inches from iron shoe; being top of copper bolt leaded vertically.	142.4204	467.263
T. B. M. 108	Is 3,080 feet east of lock No. 6, about 10 feet east from telegraph pole 4, at edge of bank, 10 feet south from center of track on a large rock; being highest point in square.	142.1768	466.464
P. B. M. 24 Six Mile Creek.	On Muscle Shoals Canal, at railroad bridge, at Sixmile Creek, on west abutment, north side; being top of copper bolt leaded vertically.	142.4825	467.466
T. B. M. 109	Is about 1¼ miles above lock 6, 100 feet east of section posts 22 and 23, 8 feet south of center of track, and 2½ feet north of telegraph pole; being highest point in square on embedded rock.	142.3625	467.073
P. B. M. 25	Is on Muscle Shoals Canal, between locks 5 and 6, at railroad bridge over Fourmile Branch, on south end of west abutment, on second step from top, 5 inches south of south edge of coping and 6 inches west of east edge of abutment; being a copper bolt leaded vertically.	142.5208	467.592
T. B. M. 113 Lock 5.	At lock No. 5, Muscle Shoals Canal, on coping at the south side and west end; being highest point in square.	146.0612	479.208
P. B. M. 26	At lock No. 5, Muscle Shoals Canal, on the south wall, on the outer corner of coping at recess of west gate, 10 inches from either face of masonry; being top of copper bolt leaded vertically.	146.0547	479.186
P. B. M. 27 Douglass Branch.	Is about 800 feet above lock 5, on the west abutment of railroad bridge over Douglass Branch, on coping at south end, 8 inches from either face; being top of copper bolt leaded vertically.	146.0816	479.275
T. B. M. 114	Is on line of Muscle Shoals Canal, about 3,200 feet east from lock No. 5, west of section posts 14–15, between telegraph poles 7 and 8, 12 feet south from center of track; being highest point of square on rock.	145.9301	478.778
P. B. M. 28	Is 260 feet below lock No. 4, Muscle Shoals Canal, on north end of east abutment of railroad bridge, in northwest corner of stone, 9 inches from either face; being copper bolt leaded vertically.	147.1525	482.788
T. B. M. 116	Is on east end of south wall of lock No. 4, Muscle Shoals Canal, near heel post; being highest point of square cut in coping stone.	149.6006	490.820
P. B. M. 29 Lock 4.	Is at lock No. 4, Muscle Shoals Canal, on the south wall and outer corner of coping stone at recess for west gate, 10 inches from either face of masonry; being top of copper bolt leaded vertically.	149.1409	489.312
P. B. M. 30 Blue Water Creek.	Is on Muscle Shoals Canal, on the north end of west abutment of bridge across Blue Water Creek, on bridge seat stone, 5½ inches west from edge of abutment and 4½ inches south from cap corner stone; being a copper bolt leaded vertically.	150.9799	495.345
T. B. M. 118	Is at lock No. 3, Muscle Shoals Canal, on south wall, east end, near the A strap; being highest point in square cut on coping.	152.8103	501.351
P. B. M. 31 Lock 3.	Is at lock No. 3, Muscle Shoals Canal, on the south wall, and outer corner of coping at recess for west gate, 10 inches from either face of masonry; being top of copper bolt leaded vertically.	152.8025	501.325
T. B. M. 119	Is 3,760 feet east of lock No. 3, 18 feet east of telegraph pole 4, west from section posts 7–8, 6 feet south of center of track; being highest point in square cut on stone.	152.8981	501.639
T. B. M. 120	Is 2,530 feet west of lock No. 2, 110 feet east of telegraph pole 11 (the second pole east of section posts 6–7), 6 feet south of center of track; being highest point in square cut on rock.	153.4511	503.453

Description and elevation of precise-level bench marks, etc.—Continued.

Number.	Description.	Elevation.	
		Meters.	Feet.
T. B. M. 121..... Lock 2.	Is at lock No. 2, Muscle Shoals Canal, on south wall, south of east gate; being highest point in square cut in coping.	154.6566	507.408
P. B. M. 32.....	Is at lock No. 2, Muscle Shoals Canal, on the south wall and the outer corner of coping at recess for west gate, 10 inches from either face of masonry; being top of copper bolt leaded vertically.	154.6588	507.415
P. B. M. 33..... Second Creek.	Is on Muscle Shoals Canal, 1,600 feet east of lock No. 2, on east abutment of railroad bridge over Second Creek, south end, in bridge seat stone, 6 inches east of west face and 30 inches north of south face of abutment; being a copper bolt leaded vertically.	155.2543	509.369
T. B. M. 125..... Lock 1.	Is at lock No. 1, Muscle Shoals Canal, on south side, at the east end of surface wall above the upper gate, just below wing wall; being highest point in square.	157.6701	517.295
P. B. M. 34	Is at lock No. 1, Muscle Shoals Canal, on the south wall, and the outer corner of coping stone at recess for west gate, 10 inches from either face of masonry; being top of copper bolt leaded vertically.	157.6769	517.317
T. B. M. 126..... End of canal.	Is at upper end of Muscle Shoals Canal, on the south side, on old dump, between section post 1 and telegraph pole 1, 12 feet south of track center; being highest point of square on rock.	157.5908	517.035
T. B. M. 128..... Lambs Ferry.	Is 1⅝ miles above the head of Muscle Shoals Canal, and 1½ miles below Lambs Ferry, 50 feet from river bank, about 900 feet below upper end of cornfield; being spike in root of an elm tree.	155.6845	510.781
T. B. M. 130.....	Is about 2,000 feet above Lambs Ferry, 100 feet from shore line, at edge of cornfield, on white oak stump 30 inches in diameter; being spike in root.	157.2825	516.023
T. B. M. 133.....	Is 820 feet east of Sycamore Landing, 40 feet from river bank and 20 feet south from wagon road, in a large red oak tree, blazed; being spike in root.	157.9546	518.228
P. B. M. 35..... Sycamore Landing.	Is on the north bank of the Tennessee River at Sycamore Landing, 78 feet above the dripping spring and 154 feet in direct line from top of bank in road to ferryboat, 25 feet below a pin-oak tree, 2½ feet in diameter, in a very prominently exposed ledge, 9 inches above ground, on shelf of rock, an arrow cut on vertical front face of rock just above points to the bench; which is a copper bolt leaded vertically.	158.9813	521.597
P. B. M. 36	Is a short distance above P. B. M. 35, where wagon road comes within 24 feet of face of bluff, 95 feet from top of river bank, 30 feet below prominent point of rock at angle of ledge, 10 feet upstream from large overhanging oak tree growing on top of ledge, an arrow is cut into face of rock pointing toward the bench; which is a copper bolt leaded horizontally.	159.9943	524.921
T. B. M. 134..... River crossing.	Is in the middle of the river on the north side of Gourd Island, at edge of bank, 60 feet from cabin belonging to Weaver Fuqua, and 100 feet from corncrib, on a large elm tree; being a spike in root.	157.5323	516.843
T. B. M. 135	Is on the south side of Weavers Island, on south side of cornfield at edge of high bank, 1⅝ miles below lock B, Elk River Canal, on a very prominent elm tree 3½ feet in diameter; being spike in root.	157.6015	517.070
T. B. M. 136	Is 1½ miles below lock B, Elk River Canal, about 460 feet above T. B. M. 135, on south side of canal chute and north edge of cultivated field; being spike in root of a dead tree.	158.3572	519.549
T. B. M. 137	Is 1 mile below lock B, Elk River Canal, 52 feet east of rail fence, near bank of river; being nail in root of locust tree.	157.6665	517.283
P. B. M. 37	Is 1 mile below lock B, Elk River Canal, 25 feet from shore line and 26 feet east of fence meeting bluff, in face of rock bluff; being a copper bolt leaded horizontally.	162.1444	531.974
T. B. M. 138	Is ¾ of a mile below lock B, Elk River Canal, 30 feet back from lower bank of river, close to a large white oak tree, 440 feet west of an ash and red elm tree that connect about 14 feet above the ground; being spike in root of a linn tree.	158.6697	520.575
P. B. M. 38	Is about ¾ of a mile below lock B, Elk River Canal, in face of rock bluff above root of uprooted linn tree that leans against bluff, 65 feet above path, 16 inches above ground; being copper bolt leaded horizontally.	165.3253	542.411
T. B. M. 140 ..... Lock B.	Is at lock B, Elk River Canal, on the north side, east gate, between A straps; being highest point in square cut in coping.	160.2320	525.700
P. B. M. 39	Is at lock B, Elk River Canal, on the south wall and outer corner of coping at recess for lower gate, 8 inches from either face of masonry; being top of copper bolt leaded vertically.	160.2365	525.715
P. B. M. 40..... Lock A.	Is at lock A, Elk River Canal, on the south wall and outer corner of coping at recess for lower gate, 10 inches from either face of masonry; being top of copper bolt leaded vertically.	162.8718	534.361

Description and elevation of precise-level bench marks, etc.—Continued.

Number.	Description.	Elevation.	
		Meters.	Feet.
T. B. M. 141	Is at lock A, Elk River Canal, on the south wall, east end, and about 10 inches from north edge of masonry; being highest point in square cut in coping.	163.3381	535.891
P. B. M. 41	Is on south shore of Elk River Canal, 690 feet east of lock A, 38 feet south from shore of canal, in exposed ledge of rock 2½ feet above ground and 1 foot from edge of ledge; being top of copper bolt leaded vertically.	162.3941	532.794
P. B. M. 42	Is at the head of Elk River Canal, 1,690 feet above lock A, on east wall of wasteweir, 6 inches from south edge of stone, and 7 inches east of timbering; being top of copper bolt leaded vertically.	162.8722	534.362
T. B. M. 142	Is 1,440 feet above lock A, Elk River Canal, on top of dam or canal wall; being highest point of square cut on big rock.	162.1014	531.833
P. B. M. 43 Miltons Bluff.	Is on the gauge pier of canal wall or dam opposite Miltons Bluff and 1.2 miles above lock A, on south side 2½ feet above top of wall of dam in top of large center stone; being top of copper bolt leaded vertically.	162.5578	533.331
T. B. M. 143	Is on the south shore of canal at Miltons Bluff, 5 feet from water, and a short distance east of old derrick, on a large flat rock; being highest point in square.	162.1203	531.895
T. B. M. 146	Is 1¼ miles above Miltons Bluff, in strip of brush between two small cornfields, about 200 feet south of river bank, on a large oak tree; being highest point in square.	163.0954	535.095
T. B. M. 150	Is 3 miles east of Miltons Bluff, in canebrake 125 feet south of river, on a large elm tree; being spike in its root.	163.3249	535.848
P. B. M. 44	Is midway between Miltons Bluff and Browns Ferry, ½ mile below Robinsons Landing, 590 feet below end of Robinson's field, in woods on top of bank by side of path, 9 feet from two blazed elms, on a stone monument marked "U. S.," set in summer of 1892 in connection with survey made to examine the "south channel;" being top of copper bolt leaded vertically and set at center of cross on stone.	163.5017	536.428
T. B. M. 151	Is about ¼ of a mile above P. B. M. 44, in Robinson's cornfield, on north side of road at top of bank, 400 feet east of property line; being spike in large sycamore stump.	163.4565	536.279
T. B. M. 153 Mallard Creek.	Is 390 feet above bridge over Mallard Creek on north side of road; being spike in root of a sycamore stump.	164.3110	539.083
T. B. M. 155	Is 1⅛ miles below Browns Ferry, 1,000 feet east of cabin on the north edge of road; being spike in stump.	165.7350	543.755
P. B. M. 45 Browns Ferry.	Is 700 feet below Browns Ferry, 180 feet below where the road turns away from the river, on north edge of wagon road on top of river bank, on a stone post standing 4 inches above the ground and marked "U. S.," set in connection with survey of 1892; being a copper bolt leaded vertically into stone at center of cross.	165.0162	541.396
P. B. M. 46	Is 530 feet below Browns Ferry where the road turns away from the river, 18 feet north of center of wagon road on top of river bank, on a stone post marked "U. S.," standing 3 inches above the ground, and set in 1892; being top of spike leaded vertically.	165.2318	542.104
T. B. M. 156	Is at Browns Ferry at the landing; being spike in root of a large sycamore tree.	163.3159	535.818
T. B. M. 158	Is ¾ of a mile above Browns Ferry, 115 feet from river at edge of cultivated field; being spike in root of sycamore stump.	165.5620	543.187
T. B. M. 159 Foxes Creek.	Is 4,700 feet below Foxes Creek; being a spike in root of a large oak stump.	165.9236	544.374
T. B. M. 162	Is ⅞ of a mile above Foxes Creek, about 75 feet east of board and wire fence, near river bank; being spike in white oak stump.	166.8962	547.565
T. B. M. 164	Is nearly 2 miles above Foxes Creek, in woods 75 feet from river; being a spike in a black oak stump 4 feet in diameter.	165.5583	543.175
T. B. M. 166	Is 1 mile below Finleys Landing, 980 feet from east end of field, on bank 50 feet from shore line, on a blazed hackberry tree; being spike in root.	165.3029	542.337
T. B. M. 168 Finleys Landing.	At Findleys Landing, in field near west bank of Spring Creek; being spike in root of sycamore stump.	165.6334	543.422
P. B. M. 47	Is 440 feet below Finleys Landing, in face of large rock just above path, and 20 inches above surface of ground; being a copper bolt leaded horinontally.	166.0530	544.798
T. B. M. 169	Is 3,000 feet above Finleys Landing, at edge of cultivated field owned by Samuel Lyle, on a hackberry tree 14 inches in diameter; being spike in root.	166.8374	547.372
T. B. M. 170	Is 1½ miles above Finleys Landing, on bank and edge of cornfield, 80 feet from river; being spike in root of a blazed oak tree.	167.7072	550.225
T. B. M. 172	Is 1¼ miles below the sawmill at lower extremity of Decatur, 35 feet from shore line, on a pecan tree 14 inches in diameter; being spike in south root.	164.3672	539.267
T. B. M. 173	Is ¾ of a mile below sawmill at the lower side of Decatur; being spike in south root of a large elm between bank and river shore.	164.9989	541.340

Description and elevation of precise-level bench marks, etc.—Continued.

Number.	Description.	Elevation.	
		Meters.	Feet.
T. B. M. 176	Is in Decatur, ½ mile below the Memphis and Charleston Railroad Bridge, on "Slick Rock," 3 feet south of river shore and 0.8 foot above water at medium stage; being highest point in square cut on rock.	163.0200	534.847
P. B. M. 48	Is in Decatur, Ala., ½ mile below Memphis and Charleston Railroad Bridge, on "Slick Rock," but a few feet from T. B. M. 176, in recess in second shelf below top of rock, 3½ feet above ordinary stage of water; being a copper bolt leaded vertically.	163.7900	537.373
P. B. M. 49	Is in Decatur, Ala., 740 feet below the Memphis and Charleston Railroad Bridge, on first point of prominent rocks below bridge, 18 feet below a leaning elm tree 1 foot in diameter, 6 feet above medium stage of water, on vertical face of rock, nine-tenths of a foot above ground and 7½ inches west of drill mark of blast; being a copper bolt leaded horizontally.	165.8811	544.234
T. B. M. 177	Is about 950 feet below Memphis and Charleston Railroad Bridge, in Decatur, Ala., 40 feet south of river shore, on a lone sycamore tree; being spike in south root.	164.2776	538.973
Gauge at Decatur (zero of).	Is a staff gauge at lower side of pivot pier of Memphis and Charleston Bridge.	161.5413	529.996
P. B. M. 50	Is in Decatur, Ala., on the south abutment of Memphis and Charleston Bridge. on the downriver end of the abutment, 6 inches south of river face of stone, in the ninth course of masonry from top and 3½ feet above ground; being a copper bolt leaded horizontally.	168.3550	552.351
Old B. M. "U. X S."	Is in Decatur, Ala., on the west end of the south abutment of Memphis and Charleston Bridge, on bridge seat stone, 1 foot from its west edge, marked "U. X S.," the part taken being the rounded point in the top of the X.	171.7863	563.608
P. B. M. 31	Is in Decatur, Ala., on the draw pier of the Memphis and Charleston Railroad Bridge across the Tennessee River, on downstream side of draw, inside of rack; being top of copper bolt leaded vertically.	171.1701	561.587
Old railroad B. M..	Is on pier of fixed span just north of draw on top surface of coping, downriver side, and corner toward Decatur.	172.0167	564.364
P. B. M. 52	Is opposite Decatur, Ala., in second pier from the north end of bridge, on the upriver end of pier; being top of copper bolt leaded vertically.	171.9539	564.158

Description and elevation of precise-level bench marks between Riverton Junction and 4 miles below Pittsburg Landing, Tenn.

Number.	Description.	Elevation.	
		Meters.	Feet.
T. B. M. G	Is 4¾ miles below Riverton Junction on line of Birmingham,	127.2530	417.500
Riverton Junction.	Sheffield and Tennessee Railway, on west side of track, south side of swamp and north edge of field, 32 feet west from center of track; being a spike in root of black oak tree.		
T. B. M. K	Is on line of Birmingham, Sheffield and Tennessee River Railway, 3¼ miles south of corner of bluff at Riverton, 65 feet east of center of track, at south corner of fence around field, 98 feet north of highway crossing; being spike in the east root of a blackthorn stump.	123.5204	405.254
T. B. M. M	Is on line of the Birmingham, Sheffield and Tennessee River Railway, 1¾ miles south of point of bluff at Riverton, 70 feet west of track, in front yard of Mrs. Mary A. Terry, on large mulberry tree, the farthest south of four in line; being spike in root.	124.8881	409.741
T. B. M. O	Is at Riverton on line of Birmingham, Sheffield and Tennessee River Railway, at the point of bluff, 185 feet south of the surface crossing of main road, 42 feet east of center of track; being spike in root of a white oak tree 1 foot in diameter.	123.6701	405.746
T. B. M. P	Is in the west extremity of Riverton, on the east side of fence near P. B. M. 4, 25 feet from top of bank, on the east root of a very large locust stump; being spike in root.	120.9526	396.830
P.B.M. 4	Is in the western extremity of Riverton, near T. B. M. P.,	120.8234	396.406
Riverton.	about ½ mile below the depot, 27 feet from river bank and 1½ feet east of farm fence running to the river, a stone post 4 feet long standing 6 inches above top of ground; being a copper bolt leaded vertically.		
T. B. M. Q., old B. M.	Is in Riverton, Ala., about 800 feet east of depot, and 50 feet south from center of track, on a large sycamore tree; being nail in root.	119.7567	392.906

Description and elevation of precise-level bench marks, etc.—Continued.

Number.	Description.	Elevation.	
		Meters.	Feet.
Lift Lock center line stone 3.	Is ¾ of a mile above Riverton on Section No. 11 of Colbert Shoals Canal, above the Lift Lock, a stone for marking the center line of canal; being the southeast corner of stone.	117.3486	385.006
P. B. M. 5, gauge B. M.	Is ¾ of a mile above Riverton, 1,200 feet south of Lift Lock, Colbert Shoals Canal, in cultivated field on conspicuous Indian mound; being highest point of limestone post set in ground = old gauge B. M.	125.0119	410.148
P. B. M. 6, U. S. building reservation.	Is ½ a mile above Lift Lock, Colbert Shoals Canal, in limestone post marking the south corner of "U. S. building reservation," opposite Station 33 of canal, 10 feet north of highway and 13 feet south of road fence; being a copper bolt leaded vertically into the northeast corner of post.	127.3883	417.945
T. B. M. 178	Is nearly a mile below Riverton Depot, on top of river bank and side of road, in root of hackberry tree; being top of spike.	118.2601	387.996
Old B. M. 3 Big Bear River.	Established 1894, 400 feet below mouth of Big Bear River, on the large cypress tree 3½ feet in diameter; being nail in base of tree.	112.5804	369.361
P. B. M. 53 Eastport.	Is 2 miles below Riverton, ⅓ of a mile below Big Bear River, directly back from Eastport Landing, in creek bed at foot of bluff, 130 feet up the creek from fence. A white oak tree, on east side of creek 11 inches in diancter, is blazed facing the bench. On east side of creek bed, 2.9 feet back from top edge of long unbroken step of rock of 9 inches rise and extending clear across creek, in broken angle formed by next step which is worn through in middle where water runs over it, 5½ inches north of this second step and 7½ inches west of other part of same step; being top of copper bolt leaded vertically.	122.1432	400.736
T. B. M. 184 Paynes Landing.	Is 2¼ miles below Big Bear River in field of the Payne estate, on river bank; being spike in root of black locust tree.	120.1146	394.080
T. B. M. 185	Is 500 feet below Paynes Landing, 5 feet back from top edge of bank and 95 feet east of ditch; being spike in base of small oak tree.	119.4859	392.018
P. B. M. 54	Is 2¾ miles below Big Bear River on property of Mr. Joe Payne, a short distance below Paynes Landing, in woods on slope, at foot of bluff, about 40 feet to the east of a beech tree standing on top of bluff and 60 feet to the north of a hickory tree, in first ledge of rock below Paynes Landing, 14 inches above ground; being center of punch mark in a copper bolt leaded horizontally.	120.3084	394.716
T. B. M. 186	Is about 3,600 feet below Paynes Landing, 360 feet west of Browns Slough, on a linn tree blazed and standing 40 feet south of shore; being spike in root.	116.9539	383.678
Old B. M. 8	Is at Browns Landing, 15 feet below edge of bank, on a red oak tree 3 feet in diameter; being nail in base of tree.	116.0421	380.719
T. B. M. 187	Is in lower end of same field which contains Browns Landing, 425 feet below two walnut trees in field, 50 feet south of river shore; being spike in base of pin-oak tree.	118.4260	388.540
P. B. M. 55	Is a quarter of a mile above Indian Creek on land of R. W. Busbee, at foot of bluff, 50 feet from fence, 20 feet back from black walnut tree 15 inches in diameter, and 20 feet from hickory tree deeply blazed toward the bench. On rounding ledge east of creek, 2½ feet above ground, just below and 5 inches from first vertical shelf; being top of copper bolt leaded vertically.	125.1962	410.752
Old B. M. 10 Indian Creek.	Is 300 feet above Indian Creek between shore and top of bank; being a nail in sycamore tree 2½ feet in diameter, established in fall of 1894.	111.3590	365.355
T. B. M. 189	Is on east bank of Indian Creek, 80 feet up the creek from river bank, on box elder tree; being spike in root.	117.7248	386.240
T. B. M. 191	Is a half mile below Cooks Landing, on west bank of large slough, a few hundred feet above where path turns off that leads to very large spring; being spike in root of sweet gum tree.	117.9170	386.870
P. B. M. 56	Is at Buggs Landing, Tishomingo County, Miss., 0.4 of a mile from the river, on the left or north bank of Whetstone Creek, 78 feet above where the road crosses it, in front (vertical) face of the slate-like rock where it has split off and fallen into creek, 2 feet above the east part of this vertical face and 1 foot above ground; being a copper bolt leaded horizontally.	112.0036	367.469
T. B. M. 192	Is a few hundred feet above Buggs Landing, 390 feet below Whetstone Creek, and 125 feet east of road to landing; being a spike in root of lone black walnut tree.	117.3828	385.118
T. B. M. 193 Robinsons Landing.	Is at Robinsons Landing, on top edge of bank, about 3,000 feet below Whetstone Creek; in field on a black walnut tree 22 inches in diameter; being spike in root.	119.2508	391.246
T. B. M. 194	Is ½ mile below Robinsons Landing, on Mr. Sam Buggs's land, on edge of bank; being spike in root of a hickory tree.	116.9811	383.800

Description and elevation of precise-level bench marks, etc.—Continued.

Number.	Description.	Elevation.	
		Meters.	Feet.
P. B. M. 57	Is at foot of bluff, ½ mile below Buggs Landing, on land of Mr. Sam Buggs, about 245 feet below ravine running into bluff, in small grotto at mouth of small cave, 15 feet above a beech tree 16 inches in diameter, 32 feet above fence and 60 feet below a small spring; being top of copper bolt leaded vertically into ledge of rock.	116.8407	383.339
T. B. M. 195	Is on upper side of first large ditch above Yellow Creek, 75 feet back from top of bank in lower end of field containing Robinsons Landing; being spike in root of black walnut tree 8 inches in diameter.	117.5221	385.575
T. B. M. 196 ..... Hubbards Landing.	Is 1½ miles above Yellow Creek, 50 feet below path down bank at Hubbards Landing, on lone hollow beech tree at top edge of bank; being spike in west root.	119.9175	393.434
Old B. M. 16.....	Is at Hubbards Landing, opposite lower end of State Line Island, 15 feet below top of bank, on a white oak tree 3 feet in diameter; being nail in root.	118.7987	389.763
T. B. M. 197	Is ½ mile above Yellow Creek, at top of bank and edge of Johnson's cornfield; being spike in root of 14-inch hackberry.	117.8074	386.511
P. B. M. 58	Is ½ mile above Yellow Creek on the Widow Johnson's estate, at second "rock waterfall" above the creek, on the second shelf from the bottom, which shelf is 2 feet wide and extends entirely across the creek, 8 feet below the center of waterway, directly below a 6-inch white ash tree, blazed toward bench that elbows out from rocks, about 25 feet above an elm blazed facing the bench; being a copper bolt leaded vertically. Messrs. C. C. Johnson and J. B. Bullard saw the bench set.	122.9150	403.268
T. B. M. 198 ..... Yellow Creek.	Is on the right bank of Yellow Creek, 10 feet below top of bank and 33 feet above point of river bank; being spike in root of oak stump.	116.8490	383.366
T. B. M. 199	Is 490 feet below the mouth of Yellow Creek, on top edge of bank, on land of Griff Johnson; being spike in root of an oak tree.	118.3659	388.343
T. B. M. 200	Is about ⅜ of a mile below Yellow Creek, on top edge of bank; being a spike in base of a large white oak tree.	117.4150	385.223
T. B. M. 202 ..... Winn Spring.	On the top of left bank of Winn Creek, 60 feet above its mouth; being a spike in root of a blazed oak tree.	117.2366	384.638
P. B. M. 59.....	Is about 1½ miles below Yellow Creek, on the Winn estate, in the large ledge directly over the center of the inlet of the famous Winn Spring, 2 feet above the water surface; being the top of a copper bolt leaded vertically.	111.3709	365.393
T. B. M. 205.....	Is 1⅝ miles below Winn Spring, at the upper point of big wash in main bank ¾ of a mile below Brushy Creek or slough, 15 feet back from top of river bank, on a red oak tree 7 inches in diameter; being spike in base.	119.0989	390.748
T. B. M. 206.....	Is 1 mile above Boyds Landing, 850 feet above pen for feeding cattle, on Budd Pratt's land, on high ridge of bank, 490 feet below short, high levee, 15 feet back from top edge of bank on a black locust tree 7 inches in diameter; being spike in base.	119.1084	390.779
T. B. M. 207 ..... Boyds Landing.	Is at Boyds Landing, on Jake Tacker's land, 75 feet below road on top edge of bank; being spike in root of a hackberry tree 2 feet in diameter.	116.7551	383.058
T. B. M. 208.....	Is about ½ mile below Boyds Landing, opposite Gibbs Post-Office, 425 feet above Edwards Landing, 230 feet above small creek running from large slough, on land of Mr. Rhodes in upper part of big cane just above the wide, low slough; being spike in south root of a hackberry tree 1½ feet in diameter.	115.4374	378.735
P. B. M. 60.....	Is on the road up the bluff from Boyds, Edwards, and Duncans landings, at intersection of Pickwick road and Rocky Branch, at foot of bluff, just opposite where road crosses creek, and on west side of road, at the lower part where shale rock shows as bed of creek, on shelf of shale rock about 2 feet above ground, opposite and 39 feet from red oak tree blazed in the form of an elipse, facing the bench; being a copper bolt leaded vertically.	121.2686	397.866
T. B. M. 212.....	Is 1¼ miles above Sulphur Creek, on land belonging to the White heirs, 100 feet back from top of bank, 48 feet from the large beech tree with very large knot on south side near ground; being spike in root of a 14-inch hard maple.	118.1780	387.727
Old B. M. 30.....	Is about 650 feet below a point opposite Pyburn Bluff, on slope of bank 30 feet from top; being nail in root of a large red oak tree.	111.2507	364.999
T. B. M. 214.....	Is about 1,150 feet above Sulphur Creek, 50 feet back from top of bank, on lower side of path leading back to farm house; being spike in the lower root of an 18-inch elm.	116.0372	380.703
T. B. M. 215 ..... Pickwick Landing.	Is at Pickwick Landing, on edge of river bank; being spike in root of an 8-inch hackberry tree.	118.6015	389.116

Description and elevation of precise-level bench marks, etc.—Continued.

Number.	Description.	Elevation.	
		Meters.	Feet.
Old B. M. 32	Is at Pickwick Landing, on steep slope near foot of bank, 30 feet above the road running down the bank to landing; being nail in root of a sycamore tree 3 feet in diameter.	112.2880	368.402
T. B. M. 216	Is ½ mile below Pickwick Landing, 30 feet back from top of bank on the field side of wagon road, in edge of field; being spike in the root of a sweet gum tree 3½ feet in diameter.	118.5068	388.805
T. B. M. 217	Is 1 mile below Pickwick Landing, on land of Mr. Luther Crow; being spike in root of a hard maple tree at edge of bank.	119.5444	392.210
T. B. M. 218 North Carolina Landing.	Is at North Carolina Landing, 1⅝ miles below Pickwick Landing, 260 feet above Robinson Creek, on edge of bank; being spike in root of a pin oak tree.	117.3290	384.941
T. B. M. 219 Chambers Creek.	Is 75 feet below the lower bank of Chambers Creek and 25 feet from river bank; being spike in root of an 18-inch black walnut.	117.2197	384.582
T. B. M. 221	Is about 1¾ miles below mouth of creek at the upper end of narrow neck of land between Chambers Creek and the river, on edge of river bank, being spike in root of a white oak tree.	116.4012	381.897
T. B. M. 223	Is 1¼ miles above Hamburg, 75 feet back from top edge of bank, on a lone pin oak 18 inches in diameter; being spike in base.	116.4347	382.007
Old P. B. M. 1	Is ¾ of a mile above Hamburg Landing on the very large boulder of concrete rock at the base of bank, 10 feet outside of line of trees and brush, two trees standing near by are blazed; being top of iron bolt leaded vertically in rock, standing 1½ inches above surface of rock.	105.9560	347.628
T. B. M. 224	Is ½ mile above Hamburg Landing at top of bank; being spike in root of a sweet gum tree 20 inches in diameter.	115.7190	379.659
T. B. M. 225 Hamburg Landing.	Is at Hamburg, 125 feet above landing and 25 feet back from top of bank; being spike in root of a black locust tree 5 inches in diameter.	116.2768	381.489
Old B. M. O	Is at Hamburg at foot of bank, 300 feet above landing; being three nails driven in a hornbean tree.	107.1288	351.476
Old B. M. 1 Hamburg Ferry.	Is 1 mile below Hamburg Landing at foot of bank, 50 feet below Hamburg Ferry; being nail in base of the upper side of birch tree 12 inches in diameter, the letters U. S. B. M. are branded in blaze directly above the point.	106.9188	350.786
T. B. M. 228 Browns Ferry.	Is ½ mile below Lick Creek, on top of river bank, in woods, 25 feet north of edge of field, in a cluster of four large trees all contained within a circle of 4 feet diameter; being spike in the west root of an 18-inch ash tree.	114.3437	375.147
T. B. M. 230	Is 655 feet below Browns Ferry, 23 feet below fence and 25 feet back from top of river bank; being spike in the root of a sweet gum tree 2 feet in diameter.	114.5092	375.690
Old B. M. 3 Pittsburg Landing.	Is at Pittsburg, 50 feet below ferry landing and 75 feet below a dry run; being a nail in the base of an 18-inch willow tree, on upper side.	108.2212	355.060
Old P. B. M. 2	Is at Pittsburg Landing in wall of National Cemetery, in that portion parallel to the river, about 500 feet above the northeast corner of wall in center of coping stone; being a ¾-inch iron bolt leaded vertically and standing an inch above surface of stone.	116.9354	383.650
P. B. M. 61	Is at Pittsburg Landing, Tenn., in coping stone of wall of National Cemetery, about 325 feet above its northeast corner and about 2 feet beyond angle in wall; being copper bolt leaded vertically.	127.1464	417.151
T. B. M. 232	Is nearly ½ mile below Pittsburg Landing, about 18 feet in cane from edge of field at top of bank; being spike in root of a locust tree 1 foot in diameter.	116.9435	383.676
T. B. M. 233 Snake Creek.	Is about 320 feet below the mouth of Snake Creek, at top of bank in canebrake, on the west side of path; being a spike in north root of a very large hollow beech tree.	116.2740	381.480
T. B. M. 234	Is ¼ of a mile below the mouth of Snake Creek, 250 feet below the light at head of Diamond Island; being a spike in a small, new, locust stump.	116.1485	381.068
T. B. M. 237	Is about 2 miles below Snake Creek, about ¼ of a mile below point where river turns sharply to the east, about 600 feet from the river bank in low place in field; being a spike in root of a lone elm tree.	113.6886	372.997
T. B. M. 238	Is ⅞ of a mile below T. B. M. 237, about 15 feet in a canebrake; being spike in root of a hackberry tree 20 inches in diameter.	112.8121	370.122
T. B. M. 239	Is 3 miles below Snake Creek, 60 feet below mouth of small branch about 65 feet below Old B. M. 6 of 1894, on slope of bank, 35 feet above river; being a spike driven in the base of a hackberry tree 3 feet in diameter.	109.5082	359.282
T. B. M. 240	Is in same locality as 239, 30 feet from shore line and about 25 feet above small branch; being spike in root of maple tree.	108.7476	356.787
Old B. M. 6	Is 3 miles below Snake Creek at mouth of small branch near edge of water of river, on a willow tree 18 inches in diameter; being head of a boat spike driven into north side of tree.	105.0631	344.698

TABULATION OF RESULTS OF PRECISE-LEVEL WORK FROM CORINTH, MISS., TO DECATUR, ALA., AND FROM RIVERTON JUNCTION TO 4 MILES BELOW PITTSBURG LANDING, TENN.

Column 1 gives the character and number of the bench marks and names of places. An asterisk indicates that the bench mark is not in the main line of levels. P. B. M. = permanent bench mark. T. B. M. = temporary bench mark.

Column 2 gives the bench mark from which the bench mark in column 1 was established.

Column 3 gives the length of line between the bench marks in columns 1 and 2.

Column 4 gives the distance as run from the initial point to the bench mark in column 1.

Column 5 gives the direction that each line was run. Dir. = direct; signifies from a bench, the elevation of which is first known, to the bench to be determined from it. Rev. = reverse, from the unknown to the known.

Column 6 gives the difference of elevation between the two bench marks, as found in each run, with its sign; also the mean difference. + signifies that the unknown (forward) bench is higher than the known bench. — signifies that it is lower. A (†) dagger indicates that the run is rejected, and so is not considered in the mean.

Column 7 gives the residuals or quantity to apply to each run to bring it to the mean.

Columns 8 and 9 give the algebraic summations of the residuals in the direct and reverse lines, from the starting point, and show how far these lines are from the mean at any bench.

Column 10 gives the probable error (r) in the mean difference of elevation for each stretch, and is, $r = 0.6745\sqrt{\frac{\Sigma v^2}{m(m-1)}}$.

Column 11 gives the probable error (R) in the elevation of the point as found, from the initial point, and is $R = \sqrt{\Sigma r^2}$.

Column 12 gives the rod correction, a quantity to be applied to the elevation first obtained, to give the elevation that would have been obtained had the meter rods used been of standard length.

Columns 13 and 14 give elevations in meters and feet, with corrections applied, above the Mississippi River Commission's preliminary mean gulf level at Biloxi. To reduce these elevations to Cairo datum add 21.258 feet, and to reduce them to Memphis datum add 8.128 feet. Value of a meter used = 3.2808693 feet. Value of a foot becomes 0.3047973 meter.

Column 15 gives the former elevations of points as determined by common levels.

Column 16 gives corrections to former elevations to bring them to precise elevations.

Column 17 gives the observers: F. = O. W. Ferguson; W. = F. B. Williams; N. = N. E. Ferguson.

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
U. S. B. M. Memphis.												80.19881	263.122			
Mean of U. S. C. and G. S. B. M's V. and W.	Memphis.		0.000		+57,210.50							137.40931	450.822	450.321 U. S. C. and G. S.	+0.501	
T. B. M. 1 Corinth.	B. M. V.	38	0.038	Dir Rev Mean	— 419.80 — 419.80 — 419.80	0.00 0.00	0.00	0.00	0.00	0.0	— 0.05	136.96061	449.350			F.
T. B. M. 1	B. M. W.	37	0.037	Dir Rev Mean	— 476.80 — 477.20 — 477.00	—0.20 +0.20	— 0.10	+ 0.10	0.13	0.1	— 0.05	136.96061	449.350			F.
*Base of rail at B. and O. and M. and C. tracks.	T. B. M. 1	383	0.420	Dir	— 3,994.80						— 0.60	132.96526	436.242			W.
T. B. M. 2	T. B. M. 1	768	0.806	Dir Rev Mean	+ 1,774.70 + 1,774.00 + 1,774.35	—0.35 +0.35	— 0.45	+ 0.45	0.23	0.2	+ 0.18	138.73519	455.172			W.
T. B. M. 3	T. B. M. 2	1,040	1.846	Dir Rev Mean	+ 786.70 + 784.80 + 785.75	—0.95 +0.95	— 1.40	+ 1.40	0.36	0.7	+ 0.28	139.52104	457.750			F.
T. B. M. 4	T. B. M. 3	850	2.696	Dir Rev Mean	— 8,322.10 — 8,322.30 — 8,322.20	—0.10 +0.10	— 1.50	+ 1.50	0.07	0.7	— 0.84	131.19772	430.443			F.
T. B. M. 5 Water tank.	T. B. M. 4	853	3.549	Dir Rev Mean	+ 2,911.50 + 2,911.80 + 2,911.65	+0.15 —0.15	— 1.35	+ 1.35	0.10	0.7	— 0.44	134.10977	439.997			W.

T. B. M. 6	T. B. M. 5	851	4.400	Dir	+ 7,602.90	+0.95	— 0.40	+ 0.40	0.63	0.9	+ 0.58	141.71464	464.947			W
				Rev	+ 7,604.80	—0.95										
				Mean	+ 7,603.85											
T. B. M. 7	T. B. M. 6	914	5.314	Dir	+ 2,871.20	—0.30	— 0.70	+ 0.70	0.20	1.0	+ 0.97	144.58593	474.368			F.
				Rev	+ 2,870.60	+0.30										
				Mean	+ 2,870.90											
T. B. M. 8	T. B. M. 7	1,417	6.731	Dir	+ 8,073.80	—1.25	— 1.95	+ 1.95	0.83	1.1	+ 2.06	152.65957	500.856			F.
				Rev	+ 8,071.30	+1.25										
				Mean	+ 8,072.55											
T. B. M. 9	T. B. M. 8	976	7.707	Dir	+ 153.40	+0.20	— 1.75	+ 1.75	0.13	1.3	+ 2.08	152.81319	501.360			W.
				Rev	+ 153.80	—0.20										
				Mean	+ 153.60											
T. B. M. 10	T. B. M. 9	1,500	9.207	Dir	+10,588.40	+1.20	— 0.55	+ 0.55	0.80	1.5	+ 3.51	163.40422	536.108			W.
				Rev	+10,590.80	—1.20										
				Mean	+10,589.60											
T. B. M. 11	T. B. M. 10	2,005	11.212	Dir	— 3,969.40	—0.95	— 1.50	+ 1.50	0.63	1.6	+ 2.97	159.43333	523.080			F.
				Rev	— 3,971.30	+0.95										
				Mean	— 3,970.35											
T. B. M. 12	T. B. M. 11	1,027	12.239	Dir	— 6,648.50	—0.45	— 1.95	+ 1.95	0.30	1.6	+ 2.08	152.78349	501.263			F.
				Rev	— 6,649.40	+0.45										
				Mean	— 6,648.95											
T. B. M. 13 Glens.	T. B. M. 12	748	12.987	Dir	— 2,929.60	+0.65	— 1.30	+ 1.30	0.43	1.7	+ 1.68	149.85414	491.652			W
				Rev	— 2,928.30	—0.65										
				Mean	— 2,928.95											
T. B. M. 14	T. B. M. 13	939	13.926	Dir	— 2,365.70	+0.50	— 0.80	+ 0.80	0.33	1.7	+ 1.36	147.48862	483.891			W.
				Rev	— 2,364.70	—0.50										
				Mean	— 2,365.20											
T. B. M. 15	T. B. M. 14	1,200	15.126	Dir	— 3,682.10	+0.30	— 0.50	+ 0.50	0.20	1.8	+ 0.86	143.80632	471.810			W.
				Rev	— 3,681.50	—0.30										
				Mean	— 3,681.80											

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 16	T. B. M. 15	1,220	16.346	Dir	+ 3,677.30	—0.70	— 1.20	+ 1.20	0.47	1.8	+ 1.36	147.48342	483.874			F.
				Rev	+ 3,675.90	+0.70										
				Mean	+ 3,676.60											
T. B. M. 17	T. B. M. 16	1,170	17.516	Dir	— 7,836.10	—1.00	— 2.20	+ 2.20	0.67	1.9	+ 0.30	139.64526	458.158			W.
				Rev	— 7,838.10	+1.00										
				Mean	— 7,837.10											
T. B. M. 18	T. B. M. 17	644	18.160	Dir	— 65.20	—0.25	— 2.45	+ 2.45	0.17	1.9	+ 0.30	139.57981	457.943			F.
				Rev	— 65.70	+0.25										
				Mean	— 65.45											
T. B. M. 19	T. B. M. 18	896	19.056	Dir	+ 9,696.50	—0.20	— 2.65	+ 2.65	0.13	1.9	+ 1.60	149.27741	489.760			F.
				Rev	+ 9,696.10	+0.20										
				Mean	+ 9,696.30											
T. B. M. 20	T. B. M. 19	660	19.716	Dir	— 3,793.10	+0.30	— 2.35	+ 2.35	0.20	2.0	+ 1.09	145.48410	477.314			W.
				Rev	— 3,792.50	—0.30										
				Mean	— 3,792.80											
T. B. M. 21	T. B. M. 20	1,112	20.828	Dir	— 4,784.20	+0.50	— 1.85	+ 1.85	0.33	2.0	+ 0.45	140.69976	461.618			W.
				Rev	— 4,783.20	—0.50										
				Mean	— 4,783.70											
T. B. M. 22	T. B. M. 21	1,357	22.185	Dir	+12,747.10	+2.20	+ 0.35	— 0.35	1.47	2.5	+ 2.16	153.45077	503.452			F.
				Rev	+12,751.50	—2.20										
				Mean	+12,749.30											
T. B. M. 23	T. B. M. 22	1,666	23.851	Dir	—11,200.10	—0.65	— 0.30	+ 0.30	0.43	2.5	+ 0.65	142.24851	466.699			F.
				Rev	—11,201.40	+0.65										
				Mean	—11,200.75											

*P. B. M. 1 Burnsville.	T. B. M. 23 ..	114	23.965	Dir ...	+ 781.00	+0.50	+ 0.20	— 0.20	0.33	2.5	+ 0.76	143.03012	469.263	.....	W.
				Rev ...	+ 782.00	—0.50									
				Mean .	+ 781.50										
*P. B. M. 2	T. B. M. 23 ..	72	23.923	Dir ...	— 680.60	—0.10	— 0.40	+ 0.40	0.07	2.5	+ 0.57	141.56773	464.465	.....	F.
				Rev ..	— 680.80	+0.10									
				Mean .	— 680.70										
T. B. M. 24	T. B. M. 23 ..	888	24.739	Dir ...	— 5,338.30	+0.90	+ 0.60	— 0.60	0.60	2.6	— 0.07	136.91039	449.185	.....	F.
				Rev ..	— 5,336.50	—0.90									
				Mean .	— 5,337.40										
T. B. M. 25 Yellow Creek.	T. B. M. 24 ..	1,033	25.772	Dir ...	— 1,560.20	—0.90	— 0.30	+ 0.30	0.60	2.6	— 0.28	135.34908	444.063	.....	W.
				Rev ..	— 1,562.00	+0.90									
				Mean .	— 1,561.10										
T. B. M. 26	T. B. M. 25 ..	1,488	27.260	Dir ...	+ 2,004.20	—0.50	— 0.80	+ 0.80	0.33	2.7	0.00	137.35306	450.637	.....	W.
				Rev ..	+ 2,003.20	+0.50									
				Mean .	+ 2,003.70										
T. B. M. 27	T. B. M. 26 ..	2,142	29.402	Dir ...	+ 4,004.50	—0.65	— 1.45	+ 1.45	0.43	2.7	+ 0.54	141.35745	463.775	.....	F.
				Rev ..	+ 4,003.20	+0.65									
				Mean .	+ 4,003.85										
T. B. M. 28	T. B. M. 27 ..	1,971	31.373	Dir ...	+17,827.80	—0.80	— 2.25	+ 2.25	0.53	2.8	+ 2.94	159.18685	522.271	.....	F.
				Rev ..	+17,826.20	+0.80									
				Mean .	+17,827.00										
T. B. M. 29	T. B. M. 28 ..	1,426	32.799	Dir ...	+14,263.30	+0.25	— 2.00	+ 2.00	0.17	2.8	+ 4.86	173.45232	569.074	.....	W.
				Rev ..	+14,263.80	—0.25									
				Mean .	+14,263.55										
T. B. M. 30	T. B. M. 29 ..	744	33.543	Dir ...	+ 6,507.80	+0.80	— 1.20	+ 1.20	0.53	2.8	+ 5.75	179.96181	590.431	.....	W.
				Rev ..	+ 6,509.40	—0.80									
				Mean .	+ 6,508.60										
T. B. M. 31	T. B. M. 30 ..	630	34.173	Dir ...	— 1,198.20	+0.10	— 1.10	+ 1.10	0.07	2.8	+ 5.59	178.76355	586.500	.....	F.
				Rev ..	— 1,198.00	—0.10									
				Mean .	— 1,198.10										

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 32	T. B. M. 31	1,012	35.185	Dir	— 6,331.90	+1.35	+ 0.25	— 0.25	0.90	3.0	+4.72	172.43213	565.727			F.
				Rev	— 6,329.20	—1.35										
				Mean	— 6,330.55											
* P. B. M. 3	T. B. M. 32	248	35.433	Dir	— 1,501.70	—0.25	0.00	0.00	0.17	3.0	+4.52	170.92998	560.799			W.
				Rev	— 1,502.20	+0.25										
				Mean	— 1,501.95											
T. B. M. 33 Iuka.	T. B. M. 32	962	36.147	Dir	— 4,209.30	—0.35	— 0.10	+ 0.10	0.23	3.0	+4.16	168.22192	551.914			W.
				Rev	— 4,210.00	+0.35										
				Mean	— 4,209.65											
T. B. M. 34	T. B. M. 33	966	37.113	Dir	+ 2,456.20	+0.25	+ 0.15	— 0.15	0.17	3.0	+4.49	170.67870	559.975			W.
				Rev	+ 2,456.70	—0.25										
				Mean	+ 2,456.45											
T. B. M. 35	T. B. M. 34	1,275	38.388	Dir	+ 8,100.10	+0.80	+ 0.95	— 0.95	0.53	3.0	+5.59	178.78070	586.556			F.
				Rev	+ 8,101.70	—0.80										
				Mean	+ 8,100.90											
T. B. M. 36 Water tank.	T. B. M. 35	1,076	39.464	Dir	—11,084.00	+0.10	+ 1.05	— 1.05	0.07	3.0	+4.09	167.69530	550.186			F.
				Rev	—11,083.80	—0.10										
				Mean	—11,083.90											
T. B. M. 37	T. B. M. 36	1,119	40.583	Dir	— 9,890.90	—1.60	— 0.55	+ 0.55	1.07	3.2	+2.75	157.80146	517.726			W.
				Rev	— 9,894.10	+1.60										
				Mean	— 9,892.50											
T. B. M. 38 Gravel siding.	T. B. M. 37	954	41.537	1 Dir	— 8,636.00	+2.40	+ 0.90	— 0.90	0.66	3.3	+1.59	149.16670	489.396			W.
				1 Rev	— 8,631.40	—2.20										
				2 Dir	— 8,634.10	+0.50										
				2 Rev	— 8,632.90	—0.70										
				Mean	— 8,633.60											

T. B. M. 39	T. B. M. 38	801	42.338	Dir	— 7,219.90	0.00	+ 0.90	— 0.90	0.00	3.3	+0.60	141.94581	465.706			W.
				Rev	— 7,219.90	0.00										
				Mean	— 7,219.90											
T. B. M. 40	T. B. M. 39	1,622	43.960	Dir	—10,109.70	+0.05	+ 0.95	— 0.95	0.03	3.3	—0.76	131.83480	432.533			F.
				Rev	—10,109.60	—0.05										
				Mean	—10,109.65											
T. B. M. 41	T. B. M. 40	853	44.813	Dir	— 998.00	—0.05	+ 0.90	— 0.90	0.03	3.3	—0.89	130.83662	429.258			F.
				Rev	— 998.10	+0.05										
				Mean	— 998.05											
T. B. M. 42 Pegram.	T. B. M. 41	1,420	46.233	Dir	— 3,883.30	—1.45	— 0.55	+ 0.55	0.97	3.4	—1.40	126.95136	416.511			F.
				Rev	— 3,886.20	+1.45										
				Mean	— 3,884.75											
T. B. M. 43 Big Bear River.	T. B. M. 42	1,326	47.559	Dir	— 2,064.90	—1.35	— 1.90	+ 1.90	0.90	3.5	—1.69	124.88482	409.731			W.
				Rev	— 2,067.60	+1.35										
				Mean	— 2,066.25											
T. B. M. 44 Riverton Junction.	T. B. M. 43	1,034	48.593	Dir	+ 1,139.50	—1.65	— 3.55	+ 3.55	1.10	3.7	—1.54	126.02282	413.464			W.
				Rev	+ 1,136.20	+1.65										
				Mean	+ 1,137.85											
T. B. M. 45 Margerum.	T. B. M. 44	1,175	49.768	Dir	+ 5,893.70	+0.40	— 3.15	+ 3.15	0.27	3.7	—0.74	131.91772	432.805			F.
				Rev	+ 5,894.50	—0.40										
				Mean	+ 5,894.10											
T. B. M. 46	T. B. M. 45	657	50.425	Dir	+ 2,057.00	+0.50	— 2.65	+ 2.65	0.33	3.7	—0.46	133.97550	439.556			F.
				Rev	+ 2,058.00	—0.50										
				Mean	+ 2,057.50											
T. B. M. 47	T. B. M. 46	1,442	51.867	Dir	— 443.70	—0.95	— 3.60	+ 3.60	0.63	3.8	—0.53	133.53078	438.097			F.
				Rev	— 445.60	+0.95										
				Mean	— 444.65											
T. B. M. 48	T. B. M. 47	1,424	53.291	Dir	+10,763.10	—1.15	— 4.75	+ 4.75	0.77	3.8	+0.93	144.29419	473.410			W.
				Rev	+10,760.80	+1.15										
				Mean	+10,761.95											

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

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		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 49	T. B. M. 48	1,267	54.568	Dir.	+ 3,278.00	−0.70	— 5.45	+ 5.45	0.47	3.9	+1.38	147.57194	484.164			W.
				Rev.	+ 3,276.60	+0.70										
				Mean	+ 3,277.30											
T. B. M. 50	T. B. M. 49	1,353	55.911	Dir	+ 7,383.50	+1.40	— 4.05	+ 4.05	0.93	4.0	+2.38	154.95784	508.396			F.
				Rev.	+ 7,386.30	−1.40										
				Mean	+ 7,384.90											
T. B. M. 51	T. B. M. 50	1,320	57.231	Dir	+ 4,671.50	−2.05	— 6.10	+ 6.10	1.37	4.2	+3.00	159.62791	523.718			F.
				Rev.	+ 4,667.40	+2.05										
				Mean	+ 4,669.45											
T. B. M. 52 Cherokee.	T. B. M. 51	1,126	58.357	Dir	— 1,756.20	−0.70	— 6.80	+ 6.80	0.47	4.2	+2.76	157.87077	517.953			W.
				Rev.	— 1,757.60	+0.70										
				Mean	— 1,756.90											
T. B. M. 53	T. B. M. 52	1,093	59.450	1 Dir	+ 2,358.70	+3.02	— 6.58	+ 6.58	0.84	4.3	+3.08	160.23281	525.703			W.
				1 Rev.	+ 2,363.20	−1.48										
				2 Dir	+ 2,364.30	−2.58										
				2 Rev.	+ 2,360.70	+1.02										
				Mean	+ 2,361.72											
T. B. M. 54	T. B. M. 53	1,121	60.571	Dir	— 261.70	−1.20	— 7.78	+ 7.78	0.80	4.4	+3.05	159.96988	524.840			F.
				Rev.	— 264.10	+1.20										
				Mean	— 262.90											
T. B. M. 55	T. B. M. 54	949	61.520	Dir	— 5,998.30	−0.95	— 8.73	+ 8.73	0.63	4.4	+2.24	153.96982	505.155			F.
				Rev.	— 6,000.20	+0.95										
				Mean	— 5,999.25											
T. B. M. 56	T. B. M. 55	813	62.333	Dir	— 4,716.50	−1.10	— 9.83	+ 9.83	0.73	4.5	+1.59	149.25157	489.675			W.
				Rev.	— 4,718.70	+1.10										
				Mean	— 4,717.60											

T. B. M. 57	T. B. M. 56	1,344	63.677	Dir	+ 4,805.90	+0.30	— 9.53	+ 9.53	0.20	4.5	+2.25	154.05843	505.446			W.
				Rev	+ 4,806.50	—0.30										
				Mean	+ 4,806.20											
T. B. M. 58	T. B. M. 57	1,730	65.407	Dir	— 4,263.60	—0.45	— 9.98	+ 9.98	0.30	4.5	+1.67	149.79380	491.454			F.
				Rev	— 4,264.50	+0.45										
				Mean	— 4,264.05											
T. B. M. 59 Barton.	T. B. M. 58	792	66.199	Dir	— 3,948.70	+0.45	— 9.53	+ 9.53	0.30	4.5	+1.13	145.84501	478.498			F.
				Rev	— 3,947.80	—0.45										
				Mean	— 3,948.25											
T. B. M. 60	T. B. M. 59	783	66.982	Dir	+ 786.40	—1.70	—11.23	+11.23	1.13	4.7	+1.24	146.62982	481.073			W.
				Rev	+ 783.00	+1.70										
				Mean	+ 784.70											
T. B. M. 61	T. B. M. 60	848	67.830	Dir	— 7,851.10	+0.25	—10.98	+10.98	0.17	4.7	+0.19	138.77792	455.312			W.
				Rev	— 7,850.60	—0.25										
				Mean	— 7,850.85											
T. B. M. 62	T. B. M. 61	893	68.723	Dir	— 4,761.80	—1.10	—12.08	+12.08	0.73	4.7	—0.46	134.01437	439.684			F.
				Rev	— 4,764.00	+1.10										
				Mean	— 4,762.90											
T. B. M. 63 Bear River.	T. B. M. 62	1,781	70,504	Dir	— 3,987.00	+2.20	— 9.88	+ 9.88	1.47	5.0	—1.00	130.02903	426.608			F.
				Rev	— 3,982.60	—2.20										
				Mean	— 3,984.80											
T. B. M. 64	T. B. M. 63	1,768	72.272	Dir	+ 9,915.20	—2.50	—12.38	+12.38	1.67	5.2	+0.34	139.94307	459.135			W.
				Rev	+ 9,910.20	+2.50										
				Mean	+ 9,912.70											
T. B. M. 65 Pride.	T. B. M. 64	673	72.945	1 Dir	+ 486.10	+2.72	—11.81	+11.81	0.63	5.3	+0.40	140.43195	460.739			W.
				1 Rev	+ 489.80	—0.98										
				2 Dir	+ 490.40	—1.58										
				2 Rev	+ 489.00	—0.18										
				Mean	+ 488.82											
*T. B. M. 72	T. B. M. 65	664	73.609	Dir	—10,801.10	—0.10	—11.71	+11.71	0.07	5.3	—1.05	129.62930	425.297			W.
				Rev	—10,801.30	+0.10										
				Mean	—10,801.20											

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

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		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
*T. B. M. 73	T. B. M. 72	498	74.107	Dir	— 3,119.20	+0.50	—11.21	+11.21	0.33	5.3	—1.47	126.51018	415.063			F.
				Rev	— 3,118.20	—0.50										
				Mean	— 3,118.70											
*P. B. M. 7	T. B. M. 73	10	74.117	Dir	+ 1,041.30	+0.15	—11.06	+11.06	0.10	5.3	—1.31	127.55179	418.481			F.
				Rev	+ 1,041.60	—0.15										
				Mean	+ 1,041.45											
T. B. M. 66	T. B. M. 65	486	73.431	1 Dir	+ 2,399.10	+0.93	—10.98	+10.98	0.41	5.3	+0.73	142.83231	468.614			W.
				1 Rev	+ 2,402.30	—2.27										
				2 Dir	+ 2,398.20	+1.83										
				2 Rev	+ 2,401.20	—1.17										
				3 Dir	+ 2,400.30	—0.27										
				3 Rev	+ 2,399.10	+0.93										
				Mean	+ 2,400.03											
T. B. M. 67	T. B. M. 66	1,136	74.567	Dir	— 8,216.80	—1.50	—12.48	+12.48	1.00	5.4	—0.38	134.61290	441.647			F.
				Rev	— 8,219.80	+1.50										
				Mean	— 8,218.30											
T. B. M. 68	T. B. M. 67	1,938	76.505	Dir	+12,918.40	—0.85	—13.33	+13.33	0.57	5.4	+1.36	147.53219	484.034			F.
				Rev	+12,916.70	+0.85										
				Mean	+12,917.55											
T. B. M. 69	T. B. M. 68	948	77.453	Dir	— 360.20	+0.75	—12.58	+12.58	0.50	5.4	+1.32	147.17270	482.854			F.
				Rev	— 358.70	+0.75										
				Mean	— 359.45											
T. B. M. 70	T. B. M. 69	1,197	78.650	Dir	—10,829.00	—2.05	—14.63	+14.63	1.37	5.6	—0.15	136.34018	447.314			W.
				Rev	—10,833.10	+2.05										
				Mean	—10,832.05											

T. B. M. 71	T. B. M. 70	747	79.397	1 Dir.	+ 449.10	—1.00	—15.78	+15.78	0.83	5.6	—0.08	136.78835	448.785		W.
				1 Rev.	+ 444.40	+3.70									
				2 Dir.	+ 449.40	—1.30									
				2 Rev.	+ 449.50	—1.40									
				Mean.	+ 448.10										
T. B. M. 74	T. B. M. 71	758	80.155	Dir.	+ 7,217.10	+0.10	—15.68	+15.68	0.07	5.7	+0.89	144.00652	472.467		F
				Rev.	+ 7,217.30	—0.10									
				Mean.	+ 7,217.20										
T. B. M. 75	T. B. M. 74	890	81.045	Dir.	+ 8,884.00	—0.45	—16.13	+16.13	0.30	5.7	+2.09	152.89127	501.616		F.
				Rev.	+ 8,883.10	+0.45									
				Mean.	+ 8,883.55										
T. B. M. 76	T. B. M. 75	783	81.828	1 Dir.	+ 1,241.40	—1.22	—17.25	+17.25	0.60	5.7	+2.25	154.13161	505.686		W.
				1 Rev.	+ 1,237.60	+2.58									
				2 Dir.	+ 1,241.20	—1.02									
				2 Rev.	+ 1,240.50	—0.32									
				Mean.	+ 1,240.18										
T. B. M. 77 and A	T. B. M. 76	846	82.674	Dir.	— 4,904.30	—1.35	—18.60	+18.60	0.90	5.8	+1.59	149.22530	489.589		W.
				Rev.	— 4,907.00	+1.35									
				Mean.	— 4,905.65										
T. B. M. 78	T. B. M. 77 and A.	656	83.330	Dir.	— 6,797.60	0.00	—18.60	+18.60	0.00	5.8	+0.67	142.42678	467.284		F.
				Rev.	— 6,797.60	0.00									
				Mean.	— 6,797.60										
T. B. M. 79	T. B. M. 78	864	84.194	Dir.	— 6,422.90	+0.30	—18.30	+18.30	0.20	5.8	—0.19	136.00332	446.209		F.
				Rev.	— 6,422.30	—0.30									
				Mean.	— 6,422.60										
T. B. M. 80	T. B. M. 79	879	85.073	Dir.	+ 5,527.60	+0.25	—18.05	+18.05	0.17	5.8	+0.55	141.53191	464.348		W.
				Rev.	+ 5,528.10	—0.25									
				Mean.	— 5,527.85										
*P. B. M. 8 Tuscumbia.	T. B. M. 80	184	85.257	Dir.	+ 3,583.30	—0.15	—18.20	+18.20	0.10	5.8	+1.04	145.11555	476.105		F.
				Rev.	+ 3,583.00	+0.15									
				Mean.	+ 3,583.15										

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
*P. B. M. 9	T. B. M. 80	142	85.215	Dir	+ 413.10	+0.15	—17.90	+17.90	0.10	5.8	+0.61	141.92522	465.704			F.
				Rev.	+ 413.40	—0.15										
				Mean	+ 413.25											
T. B. M. 81	T. B. M. 80	1,114	86.187	Dir	+ 5,854.00	+1.85	—16.20	+16.20	1.23	5.9	+1.35	147.38856	483.563			W.
				Rev.	+ 5,857.70	—1.85										
				Mean	+ 5,855.85											
T. B. M. 82	T. B. M. 81	1,095	87.282	Dir	+ 6,791.60	+0.05	—16.15	+16.15	0.03	5.9	+2.27	154.18113	505.848			F.
				Rev.	+ 6,791.70	—0.05										
				Mean	+ 6,791.65											
T. B. M. 83	T. B. M. 82	1,105	88.387	Dir	+ 1,325.40	0.00	—16.15	+16.15	0.00	5.9	+2.44	155.50670	510.197			F.
				Rev.	+ 1,325.40	0.00										
				Mean	+ 1,325.40											
T. B. M. 84	T. B. M. 83	1,152	89.539	Dir	+ 7,164.50	+0.30	—15.85	+15.85	0.20	5.9	+3.41	162.67247	533.707			W.
				Rev.	+ 7,165.10	—0.30										
				Mean	+ 7,164.80											
T. B. M. 85	T. B. M. 84	1,016	90.555	Dir	— 3,536.40	—1.80	—17.65	+17.65	1.20	6.0	+2.93	159.13379	522.097			W.
				Rev.	— 3,540.00	+1.80										
				Mean	— 3,538.20											
T. B. M. 86 River crossing.	T. B. M. 85	1,368	91.923	Dir	—19,039.70	+2.05	—15.60	+15.60	1.37	6.2	+0.36	140.09357	459.629			F.
				Rev.	—19,035.60	—2.05										
				Mean	—19,037.65											
*P. B. M. 10	T. B. M. 86	74	91.997	Dir	— 6,783.30	+0.15	—15.45	+15.45	0.10	6.2	—0.55	133.30951	437.371			F.
				Rev.	— 6,783.00	—0.15										
				Mean	— 6,783.15											

T. B. M. 87	T. B. M. 86	781	92.704	Dir	— 4,018.90	+0.30	—15.30	+15.30	0.20	6.2	—0.18	136.07443	446.442			F.
				Rev	— 4,018.30	—0.30										
				Mean	— 4,018.60											
*Base of rail at center of draw.	T. B. M. 87	180	92.884	Dir	+ 1,650.50	+0.55	—14.75	+14.75	0.37	6.2	+0.04	137.72570	451.860	446.8	+5.060	F.
				Rev	+ 1,651.60	—0.55										
				Mean	+ 1,651.05											
*Old gauge B. M.	T. B. M. 87	126	92.830	Dir	— 5,929.60	+0.40	—14.90	+14.90	0.27	6.2	—0.99	130.14442	426.987			W.
				Rev	— 5,928.80	—0.40										
				Mean	— 5,929.20											
*P. B. M. 11	Gauge B. M.	108	92.938	Dir	+ 211.00	—0.25	—15.15	+15.15	0.17	6.2	—0.95	130.35521	427.678			F.
				Rev	+ 210.50	+0.25										
				Mean	+ 210.75											
*P. B. M. 12	Gauge B. M.	26	92.856	Dir	+ 311.00	—0.25	—15.15	+15.15	0.17	6.2	—0.94	130.45522	428.007			W.
				Rev	+ 310.50	+0.25										
				Mean	+ 310.75											
*Zero of gauge Florence.	Gauge B. M.	266	93.096	Dir	— 9,210.40	—0.35	—15.25	+15.25	0.23	6.2	—1.49	120.93317	396.766			W.
				Rev	— 9,211.10	+0.35										
				Mean	— 9,210.75											
T. B. M. 89	T. B. M. 87	864	93.568	Dir	— 6,132.00	+0.30	—15.00	+15.00	0.20	6.2	—1.01	129.94190	426.322			W.
				Rev	— 6,131.40	—0.30										
				Mean	— 6,131.70											
T. B. M. 90	T. B. M. 89	1,234	94.802	Dir	+ 8,666.60	+0.60	—14.40	+14.40	0.40	6.2	+0.16	138.61027	454.762			W.
				Rev	+ 8,667.80	—0.60										
				Mean	+ 8,667.20											
*P. B. M. 13	T. B. M. 90	50	94.852	Dir	— 599.40	—0.30	—14.70	+14.70	0.20	6.2	+0.08	138.01049	452.794			F.
				Rev	— 600.00	+0.30										
				Mean	— 599.70											
T. B. M. 91 East Florence.	T. B. M. 90	1,425	96.227	Dir	+ 3,023.10	+1.15	—13.25	+13.25	0.77	6.2	+0.57	141.63493	464.686			F.
				Rev	+ 3,025.40	—1.15										
				Mean	+ 3,024.25											

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
*P. B. M. 14	T. B. M. 91	124	96.351	Dir	+ 1,169.40	−0.05	−13.20	+13.20	0.03	6.2	+0.73	142.80444	468.523			F.
				Rev	+ 1,169.30	+0.05										
				Mean	+ 1,169.35											
T. B. M. 92	T. B. M. 91	1,477	97.704	Dir	+ 4,495.60	+0.35	−12.90	+12.90	0.23	6.2	+1.18	146.13149	479.438			F.
				Rev	+ 4,496.30	−0.35										
				Mean	+ 4,495.95											
T. B. M. 93	T. B. M. 92	630	98.334	Dir	−13,957.90	−0.80	−13.70	+13.70	0.53	6.3	−0.70	132.17091	433.635			W.
				Rev	−13,959.50	+0.80										
				Mean	−13,958.70											
*P. B. M. 15	T. B. M. 93	82	98.416	Dir	+ 1,613.50	+0.20	−13.50	+13.50	0.13	6.3	−0.49	133.78482	438.931			W.
				Rev	+ 1,613.90	−0.20										
				Mean	+ 1,613.70											
T. B. M. 94	T. B. M. 93	613	98.947	Dir	− 3,924.70	+0.05	−13.65	+13.65	0.03	6.3	−1.24	128.24572	420.757			W.
				Rev	− 3,924.60	−0.05										
				Mean	− 3,924.65											
T. B. M. 95	T. B. M. 94	597	99.544	Dir	− 1,367.90	+0.20	−13.45	+13.45	0.13	6.3	−1.42	126.87784	416.270			F.
				Rev	− 1,367.50	−0.20										
				Mean	− 1,367.70											
*P. B. M. 16	T. B. M. 95	471	100.015	Dir	+ 5,308.40	+0.15	−13.30	+13.30	0.10	6.3	−0.70	132.18711	433.689			F.
				Rev	+ 5,308.70	−0.15										
				Mean	+ 5,308.55											
T. B. M. 96	T. B. M. 95	1,012	100.556	Dir	+ 2,597.40	+1.00	−12.45	+12.45	0.67	6.3	−1.07	129.47659	424.796			F.
				Rev	+ 2,599.40	−1.00										
				Mean	+ 2,598.40											

T. B. M. 97	T. B. M. 96	849	101.405	Dir	— 789.50	+0.45	—12.00	+12.00	0.30	6.3	—1.18	128.68743	422.207			W.
				Rev	— 788.60	—0.45										
				Mean	— 789.05											
T. B. M. 98	T. B. M. 97	159	101.564	1 Dir	+ 334.30	—0.13	—11.90	+11.90	0.10	6.3	—1.14	129.02164	423.303			W.
				1 Rev	+ 331.70†	+2.47										
				2 Dir	+ 333.90	+0.27										
				2 Rev	+ 334.30	—0.13										
				Mean	+ 334.17											
*P. B. M. 17	T. B. M. 98	10	101.574	Dir	+ 452.80	—0.05	—11.95	+11.95	0.03	6.3	—1.08	129.47445	424.789			W.
				Rev	+ 452.70	+0.05										
				Mean	+ 452.75											
T. B. M. 99	T. B. M. 98	536	102.100	Dir	+ 1,054.80	—1.25	—13.15	+13.15	0.83	6.4	—0.99	130.07534	426.760			W.
				Rev	+ 1,052.30	+1.25										
				Mean	+ 1,053.55											
T. B. M. 100	T. B. M. 99	1,085	103.185	Dir	— 250.70	+1.85	—11.30	+11.30	1.23	6.5	—1.03	129.82645	425.944			F.
				Rev	— 247.00	—1.85										
				Mean	— 248.85											
T. B. M. 101 Bainbridge.	T. B. M. 100	536	103.721	Dir	— 203.80	+0.35	—10.95	+10.95	0.23	6.5	—1.05	129.62208	425.276			F.
				Rev	— 203.10	—0.35										
				Mean	— 203.45											
T. B. M. 102	T. B. M. 101	599	104.320	Dir	+ 2,117.90	+0.60	—10.35	+10.35	0.40	6.5	—0.77	131.74176	432.228			F.
				Rev	+ 2,119.10	—0.60										
				Mean	+ 2,118.50											
*P. B. M. 18 Lock No. 9.	T. B. M. 102	388	104.708	Dir	+ 973.70	—0.40	—10.75	+10.75	0.27	6.5	—0.64	132.71519	435.421			F.
				Rev	+ 972.90	+0.40										
				Mean	+ 973.30											
*P. B. M. 19	T. B. M. 102	125	104.445	Dir	+ 6.10	+0.05	—10.30	+10.30	0.03	6.5	—0.77	131.74791	432.248			F.
				Rev	+ 6.20	—0.05										
				Mean	+ 6.15											
*Zero of gauge at lock 9.	P. B. M. 19	38	104.483	Dir	— 4,194.70	—0.05	—10.35	+10.35	0.03	6.5	—0.92	127.55301	418.485			F.
				Rev	— 4,194.80	+0.05										
				Mean	— 4,194.75											

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V.		r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi.			Correction.	Observer.
							Direct line.	Reverse line.				Meters.	Feet.	Former by common level.		
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 103..... Lock No. 8.	T. B. M. 102.	480	104.800	1 Dir.	+ 3,070.80	+0.88	— 9.27	+ 9.27	0.43	6.5	—0.35	134.81386	442.307	.....	.....	F.
				1 Rev.	+ 3,072.40	—0.72										
				2 Dir.	+ 3,070.40	+1.28										
				2 Rev.	+ 3,073.10	—1.42										
				Mean.	+ 3,071.68											
*P. B. M. 20.....	T. B. M. 103.	30	104.830	Dir...	+ 5.40	+0.05	— 9.22	+ 9.22	0.03	6.5	—0.35	134.81931	442.325	.....	.....	F.
				Rev...	+ 5.50	—0.05										
				Mean.	+ 5.45											
T. B. M. 104 ..... Lock No. 7.	T. B. M. 103.	1,231	106.031	1 Dir..	+ 2,585.90	—2.55	—10.32	+10.32	0.88	6.6	0.00	137.39756	450.783	.....	.....	W.
				1 Rev.	+ 2,579.90	+3.45										
				2 Dir..	+ 2,582.90	+0.45										
				2 Rev.	+ 2,584.70	—1.35										
				Mean.	+ 2,583.35											
* P. B. M. 21..... Shoal Creek.	T. B. M. 104.	10	106.041	Dir...	+ 1,066.30	+0.10	—10.22	+10.22	0.07	6.6	+0.14	138.46410	454.283	.....	.....	W.
				Rev...	+ 1,066.50	—0.10										
				Mean.	+ 1,066.40											
T. B. M. 105.....	T. B. M. 104.	850	106.881	Dir...	+ 1,305.80	—0.80	—11.12	+11.12	0.53	6.6	+0.18	138.70274	455.066	.....	.....	W.
				Rev...	+ 1,304.20	+0.80										
				Mean.	+ 1,305.00											
* P. B. M. 22.....	T. B. M. 105	437	107.318	Dir...	— 390.00	+0.10	—11.02	+11.02	0.07	6.6	+0.12	138.31278	453.786	.....	.....	W.
				Rev...	— 389.80	—0.10										
				Mean.	— 389.90											
T. B. M. 106.....	T. B. M. 105	869	107.750	Dir...	— 1,931.70	+1.05	—10.07	+10.07	0.70	6.6	—0.08	136.77183	448.730	.....	.....	F.
				Rev...	— 1,929.60	—1.05										
				Mean.	— 1,930.65											

T. B. M. 107..... Lock No. 6.	T. B. M. 106.	397	108.147	Dir ...	+ 4,430.20	+1.00	— 9.07	+ 9.07	0.67	6.7	+0.51	141.20362	463.271	.....	.....	F.
				Rev...	+ 4,432.20	—1.00										
				Mean .	+ 4,431.20											
*P. B. M. 23.....	T. B. M. 107.	17	108.164	Dir ...	+ 1,216.50	+0.10	— 8.97	+ 8.97	0.07	6.7	+0.67	142.42038	467.263	.....	.....	W.
				Rev...	+ 1,216.70	—0.10										
				Mean .	+ 1,216.60											
T. B. M. 108.....	T. B. M. 107.	940	109.087	Dir ...	+ 972.80	+0.25	— 8.82	+ 8.82	0.17	6.7	+0.65	142.17681	466.464	.....	.....	W.
				Rev...	+ 973.30	—0.25										
				Mean .	+ 973.05											
*P. B. M. 24..... Six Mile Creek.	T. B. M. 108.	437	109.524	Dir ...	+ 305.70	—0.05	— 8.87	+ 8.87	0.03	6.7	+0.68	142.48249	467.466	.....	.....	W.
				Rev...	+ 305.60	+0.05										
				Mean .	+ 305.65											
T. B. M. 109.....	T. B. M. 108.	1,025	110.112	Dir ...	+ 184.60	+1.10	— 7.72	+ 7.72	0.73	6.7	+0.67	142.36253	467.073	.....	.....	W.
				Rev ..	+ 186.80	—1.10										
				Mean .	+ 185.70											
T. B. M. 110.....	T. B. M. 109.	1,220	111.332	Dir ...	— 68.80	—0.15	— 7.87	+ 7.87	0.10	6.7	+0.66	142.29357	466.847	.....	.....	F.
				Rev ..	— 69.10	+0.15										
				Mean .	— 68.95											
T. B. M. 111..... Four Mile Creek.	T. B. M. 110.	1,029	112.361	Dir ...	+ 836.80	+0.20	— 7.67	+ 7.67	0.13	6.7	+0.76	143.13067	469.593	.....	.....	F.
				Rev ..	+ 837.20	—0.20										
				Mean .	+ 837.00											
*P. B. M. 25.....	T. B. M. 111.	203	112.564	1 Dir..	— 610.70	+0.92	— 7.35	+ 7.35	0.26	6.8	+0.69	142.52082	467.592	.....	.....	F.
				1 Rev .	— 608.80	—0.98										
				2 Dir..	— 609.50	—0.28										
				2 Rev .	— 610.10	+0.32										
				Mean .	— 609.78											
T. B. M. 112.....	T. B. M. 111.	1,146	113.507	1 Dir..	+ 75.30	+4.60	— 5.67	+ 5.67	1.27	6.9	+0.78	143.21059	469.855	.....	.....	W.
				1 Rev .	+ 80.50	—0.60										
				2 Dir..	+ 79.30	+0.60										
				2 Rev .	+ 84.50	—4.60										
				Mean .	+ 79.90											

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals = V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 113 ..... Lock No. 5.	T. B. M. 112 .	1,321	114.828	Dir ...	+ 2,851.30	—1.10	— 6.77	+ 6.77	0.73	6.9	+1.17	146.06118	479.208	.....	.....	F.
				Rev ..	+ 2,849.10	+1.10										
				Mean .	+ 2,850.20											
* P. B. M. 26 ..... Douglass Branch.	T. B. M. 113 .	24	114.852	Dir ...	— 6.70	+0.20	— 6.57	+ 6.57	0.13	6.9	+1.17	146.05468	479.186	.....	.....	F.
				Rev ..	— 6.30	—0.20										
				Mean .	— 6.50											
* P. B. M. 27	T. B. M. 113 .	271	115.099	Dir ...	+ 21.00	—0.55	— 7.32	+ 7.32	0.37	6.9	+1.17	146.08163	479.275	.....	.....	F.
				Rev ..	+ 19.90	+0.55										
				Mean .	+ 20.45											
T. B. M. 114	T. B. M. 113 .	1,082	115.910	Dir ...	— 130.10	+1.05	— 5.72	+ 5.72	0.70	6.9	+1.15	145.93011	478.778	.....	.....	F.
				Rev ..	— 130.00	—1.05										
				Mean .	— 131.05											
T. B. M. 115	T. B. M. 114 .	1,088	116.998	Dir ...	+ 412.10	—0.20	— 5.92	+5.92	0.13	6.9	+1.20	146.34206	480.129	.....	.....	W.
				Rev...	+ 411.70	+0.20										
				Mean .	+ 411.90											
T. B. M. 116	T. B. M. 115 .	978	117.976	1 Dir..	+ 3,256.80	+1.33	— 5.80	+5.80	0.49	6.9	+1.65	149.60064	490.820	.....	.....	W.
				1 Rev .	+ 3,251.70	+6.43										
				2 Dir..	+ 3,259.30	—1.17										
				2 Rev .	+ 3,258.30	—0.17										
				Mean .	+ 3,258.13											
* P. B. M. 28 ..... Lock No. 4.	T. B. M. 116 .	240	118.216	Dir ...	— 2,447.60	—0.25	— 6.05	+6.05	0.17	6.9	+1.31	147.15245	482.788	.....	.....	W.
				Rev...	— 2,448.10	+0.25										
				Mean .	— 2,447.85											
* P. B. M. 29	T. B. M. 116 .	82	118.058	Dir ...	— 459.40	—0.25	— 6.05	+6.05	0.17	6.9	+1.57	149.14091	489.312	.....	.....	W.
				Rev...	— 459.90	+0.25										
				Mean .	— 459.65											

*P. B. M. 117 ..... Blue Water Creek.	T. B. M. 116	1,192	119.168	Dir ...	— 937.00	+0.50	—5.30	+5.30	0.33	6.9	+1.52	148.66401	487.747	.....	.....	F
				Rev...	— 936.00	—0.50										
				Mean .	— 936.50											
T. B. M. 118 ..... Lock No. 3.	T. B. M. 117	1,323	120.491	Dir ...	+ 4,145.30	+0.40	—4.90	+4.90	0.27	6.9	+2.08	152.81027	501.351	.....	.....	F.
				Rev...	+ 4,146.10	—0.40										
				Mean .	+ 4,145.70											
*P. B. M. 30	T. B. M. 118	299	120.790	Dir ...	— 1,830.40	+0.30	—4.60	+4.60	0.20	6.9	+1.84	150.97993	495.345	.....	.....	F.
				Rev...	— 1,829.80	—0.30										
				Mean .	— 1,830.10											
*P. B. M. 31	T. B. M. 118	80	120.571	Dir ...	— 7.60	—0.15	—5.05	+5.05	0.10	6.9	+2.08	152.80252	501.325	.....	.....	F.
				Rev...	— 7.90	+0.15										
				Mean .	— 7.75											
T. B. M. 119	T. B. M. 118	1,152	121.643	Dir ...	+ 87.80	+0.05	—4.85	+4.85	0.03	6.9	+2.09	152.89813	501.639	.....	.....	F.
				Rev...	+ 87.90	—0.05										
				Mean .	+ 87.85											
T. B. M. 120	T. B. M. 119	1,175	122.818	Dir ...	+ 551.40	+1.45	—3.40	+3.40	0.97	7.0	+2.16	153.45105	503.453	.....	.....	W.
				Rev ..	+ 554.30	—1.45										
				Mean .	+ 552.85											
T. B. M. 121 ..... Lock No. 2.	T. B. M. 120	771	123.589	Dir ...	+ 1,206.90	—1.55	—4.95	+4.95	1.03	7.1	+2.33	154.65657	507.408	.....	.....	W.
				Rev ..	+ 1,203.80	+1.55										
				Mean .	+ 1,205.35											
*P. B. M. 32 ..... Second Creek.	T. B. M. 121	79	123.668	Dir ...	+ 2.30	—0.10	—5.05	+5.05	0.07	7.1	+2.33	154.65877	507.415	.....	.....	W.
				Rev ..	+ 2.10	+0.10										
				Mean .	+ 2.20											
*P. B. M. 33	T. B. M. 121	20	124.109	Dir ...	+ 597.50	+0.10	—4.85	+4.85	0.07	7.1	+2.41	155.25425	509.369	.....	.....	F.
				Rev ..	+ 597.70	—0.10										
				Mean .	+ 597.60											
T. B. M. 122	T. B. M. 121	910	124.499	Dir ...	+ 272.50	—0.25	—5.20	+5.20	0.17	7.1	+2.36	154.92885	508.301	.....	.....	F.
				Rev ..	+ 272.00	+0.25										
				Mean .	+ 272.25											

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Formed by commonlevel.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 123	T. B. M. 122	1,057	125.556	1 Dir.	+ 673.70	+1.75	—4.05	+4.05	0.77	7.1	+2.46	155.60440	510.518			F.
				1 Rev.	+ 678.80	—3.35										
				2 Dir.	+ 674.90	+0.55										
				2 Rev.	+ 674.40	+1.05										
				Mean.	+ 675.45											
T. B. M. 124	T. B. M. 123	894	126.450	Dir.	+ 1,677.70	—1.45	—5.50	+5.50	0.97	7.2	+2.68	157.28087	516.018			W.
				Rev.	+ 1,674.80	+1.45										
				Mean.	+ 1,676.25											
T. B. M. 125 Lock No. 1	T. B. M. 124	298	126.748	Dir.	+ 388.60	+0.60	—4.90	+4.90	0.40	7.2	+2.74	157.67013	517.295			W.
				Rev.	+ 389.80	—0.60										
				Mean.	+ 389.20											
* P. B. M. 34	T. B. M. 125	100	126.848	Dir.	+ 7.00	—0.20	—5.10	+5.10	0.13	7.2	+2.74	157.67693	517.317			W.
				Rev.	+ 6.60	+0.20										
				Mean.	+ 6.80											
T. B. M. 126 End of canal.	T. B. M. 125	581	127.329	Dir.	— 80.20	+0.90	—4.00	+4.00	0.60	7.2	+2.73	157.59082	517.035			W.
				Rev.	— 78.40	—0.90										
				Mean.	— 79.30											
T. B. M. 127	T. B. M. 126	1,244	128.573	Dir.	— 1,199.90	+0.95	—3.05	+3.05	0.63	7.2	+2.56	156.39170	513.101			W.
				Rev.	— 1,198.00	—0.95										
				Mean.	— 1,198.95											
T. B. M. 128	T. B. M. 127	1,413	129.986	Dir.	— 707.50	+0.40	—2.65	+2.65	0.27	7.3	+2.47	155.68451	510.781			F.
				Rev.	— 706.70	—0.40										
				Mean.	— 707.10											
T. B. M. 129 Lambs Ferry.	T. B. M. 128	1,970	131,956	Dir.	+ 703.90	0.00	—2.65	+2.65	0.00	7.3	+2.56	156.38850	513.090			F.
				Rev.	+ 703.90	0.00										
				Mean.	+ 703.90											

T. B. M. 130	T. B. M. 129	1,015	133.001	Dir ...	+ 894.80	−0.95	−3.60	+3.60	0.63	7.3	+2.68	157.28247	516.023			W.
				Rev ..	+ 892.90	+0.95										
				Mean .	+ 893.85											
T, B, M. 131	T. B. M. 130	898	133.899	Dir ...	− 205.40	+0.90	−2.70	+2.70	0.60	7.3	+2.66	157.07795	515.352			W.
				Rev ..	− 203.60	−0.90										
				Mean .	− 204.50											
T. B. M. 132	T. B. M. 131	1,304	135.203	Dir ...	+ 682.00	+0.45	−2.25	+2.25	0.30	7.3	+2.75	157.76049	517.592			W.
				Rev ..	+ 682.90	−0.45										
				Mean .	+ 682.45											
T. B. M. 133	T. B. M. 132	895	136.098	Dir ...	+ 192.80	+1.25	−1.00	+1.00	0.83	7.4	+2.78	157.95457	518.228			F.
				Rev ..	+ 195.30	−1.25										
				Mean .	+ 194.05											
* P. B. M. 35 Sycamore Landing.	T. B. M. 133	373	136.471	Dir ...	+ 1,026.40	+0.15	−0.85	+0.85	0.10	7.4	+2.92	158.98126	521.597			F.
				Rev ..	+ 1,026.70	−0.15										
				Mean .	+ 1,026.55											
* P. B. M. 36	T. B. M. 133	128	136.226	Dir ...	+ 2,039.60	−0.10	−1.10	+1.10	0.07	7.4	+3.05	159.99434	524.921			W.
				Rev ..	+ 2,039.40	+0.10										
				Mean .	+ 2,039.50											
T. B. M. 134 River crossing.	T. B. M. 133	792	136.890	Dir ...	− 423.10	+0.90	−0.10	+0.10	0.60	7.4	+2.71	157.53230	516.843			W.
				Rev ..	− 421.30	−0.90										
				Mean .	− 422.20											
T. B. M. 135	T. B. M. 134	1,006	137.896	Dir ...	+ 69.70	−0.50	−0.60	+0.60	0.33	7.4	+2.72	157.60151	517.070			F.
				Rev ..	+ 68.70	+0.50										
				Mean .	+ 69.20											
T. B. M. 136	T. B. M. 135	347	138.243	Dir ...	+ 756.10	−0.55	−1.15	+1.15	0.37	7.4	+2.83	158.35717	519.549			W.
				Rev ..	+ 755.00	+0.55										
				Mean .	+ 755.55											
T. B. M. 137	T. B. M. 136	898	139.141	Dir ...	− 691.50	+0.95	−0.20	+0.20	0.63	7.4	+2.74	157.66653	517.283			W.
				Rev ..	− 689.60	−0.95										
				Mean .	− 690.55											

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
*P. B. M. 37	T. B. M. 137	41	139.182	Dir	+ 4,477.70	—0.45	—0.65	+0.65	0.30	7.4	+3.33	162.14437	531.974			W.
				Rev	+ 4,476.80	+0.45										
				Mean	+ 4,477.25											
T. B. M. 138	T. B. M. 137	346	139.487	Dir	+ 1,003.10	—0.05	—0.25	+0.25	0.30	7.4	+2.87	158.66971	520.575			W.
				Rev	+ 1,003.00	+0.05										
				Mean	+ 1,003.05											
*P. B. M. 38	T. B. M. 138	48	139.535	Dir	+ 6,654.70	0.00	—0.25	+0.25	0.00	7.4	+3.76	165.32530	542.411			W.
				Rev	+ 6,654.70	0.00										
				Mean	+ 6,654.70											
T. B. M. 139	T. B. M. 138	537	140.024	1 Dir	— 485.80	+1.20	+1.10	—1.10	0.53	7.5	+2.81	158.18505	518.984			W.
				1 Rev	— 482.80	—1.80										
				2 Dir	— 486.10	+1.50										
				2 Rev	— 483.70	—0.90										
				Mean	— 484.60											
T. B. M. 140 Lock B.	T. B. M. 139	697	140.721	Dir	+ 2,045.30	+1.35	+2.45	—2.45	0.90	7.5	+3.08	160.23197	525.700			W.
				Rev	+ 2,048.00	—1.35										
				Mean	+ 2,046.65											
*P. B. M. 39	T. B. M. 140	84	140.805	Dir	+ 4.70	—0.15	+2.30	—2.30	0.10	7.5	+3.08	160.23652	525.715			W.
				Rev	+ 4.40	+0.15										
				Mean	+ 4.55											
*Zero of gauge at Lock B.	P. B. M. 39	172	140.977	Dir	— 5,832.90	+1.20	+3.50	—3.50	0.80	7.5	+2.68	154.40442	506.581			W.
				Rev	— 5,830.50	—1.20										
				Mean	— 5,831.70											
P. B. M. 40	T. B. M. 140	1,860	142.581	Dir	+ 2,637.80	+1.65	+4.10	—4.10	1.10	7.6	+3.44	162.87178	534.361			F.
				Rev	+ 2,641.10	—1.65										
				Mean	+ 2,639.45											

T. B. M. 141 ..... Lock A.	P. B. M. 40..	102	142.683	Dir ... + 466.10 Rev... + 466.40 Mean . + 466.25	+0.15 −0.15	+4.25	−4.25	0.10	7.6	+3.49	163.33808	535.891	.....	.....	F.
*Zero of gauge at Lock A.	T. B. M. 141.	20	142.703	Dir ... − 4,575.60 Rev... − 4,576.70 Mean . − 4,576.15	−0.55 +0.55	+3.75	−3.75	0.37	7.6	+3.35	158.76179	520.877	.....	.....	W.
*P. B. M. 41.....	T. B. M. 141.	362	143.045	Dir .. − 944.20 Rev... − 943.50 Mean . − 943.85	+0.35 −0.35	+4.60	−4.60	0.23	7.6	+3.37	162.39411	532.794	.....	.....	N.
*P. B. M. 42.....	T. B. M. 141.	520	143.203	Dir ... − 466.80 Rev... − 464.90 Mean . − 465.85	+0.95 −0.95	+5.20	−5.20	0.63	7.6	+3.44	162.87218	534.362	.....	.....	F.
T. B. M. 142	T. B. M. 141.	1,360	144.043	Dir ... − 1,236.60 Rev... − 1,236.50 Mean . − 1,236.55	+0.05 −0.05	+4.30	−4.30	0.03	7.6	+3.33	162.10137	531.833	.....	.....	F.
*Zero of gauge at Miltons Bluff.	T. B. M. 142.	544	144.587	Dir ... − 2,707.80 Rev... − 2,708.00 Mean . − 2,707.90	−0.10 +0.10	+4.20	−4.20	0.07	7.6	+3.39	159.39353	522.949	.....	.....	F.
T. B. M. 143	T. B. M. 142.	797	144.840	Dir ... + 18.60 Rev... + 19.20 Mean . + 18.90	+0.30 −0.30	+4.60	−4.60	0.20	7.6	+3.33	162.12027	531.895	.....	.....	F.
*P. B. M. 43..... Miltons Bluff.	T. B. M. 143.	245	145.085	Dir ... + 437.30 Rev... + 437.60 Mean . + 437.45	+0.15 −0.15	+4.75	−4.75	0.10	7.6	+3.39	162.55778	533.331	.....	.....	F.
T. B. M. 144	T. B. M. 143.	520	145.360	Dir ... +19,875.00 Rev... +19,875.70 Mean . +19,875.35	+0.35 −0.35	+4.95	−4.95	0.23	7.6	+6.02	181.99831	597.113	.....	.....	F.
T. B. M. 145	T. B. M. 144.	880	146.240	Dir ... −19,868.20 Rev... −19,869.00 Mean . −19,868.60	−0.40 +0.40	+4.55	−4.55	0.27	7.6	+3.33	162.12702	531.918	.....	.....	W.

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

ench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi. Meters.	Feet.	Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 146	T. B. M. 145.	616	146.856	Dir ...	+ 968.70	−0.45	+4.10	−4.10	0.30	7.6	+3.47	163.09541	535.095			W.
				Rev...	+ 967.80	+0.45										
				Mean .	+ 968.25											
T. B. M. 147	T. B. M. 146.	1,124	147.980	Dir ...	− 245.20	+1.00	+5.10	−5.10	0.67	7.6	+3.43	162.85117	534.293			F.
				Rev...	− 243.20	−1.00										
				Mean .	− 244.20											
T. B. M. 148	T. B. M. 147.	758	148.738	Dir ...	+ 831.60	−0.75	+4.35	−4.35	0.50	7.6	+3.55	163.68214	537.020			F.
				Rev...	+ 830.10	+0.75										
				Mean .	+ 830.85											
T. B. M. 149	T. B. M. 148.	446	149.184	1 Dir..	+ 185.90	+3.00	+5.65	−5.65	0.73	7.7	+3.58	163.87107	537.640			W.
				1 Rev .	+ 189.30	−0.40										
				2 Dir..	+ 189.30	−0.40										
				2 Rev .	+ 191.10	−2.20										
				Mean .	+ 188.90											
T. B. M. 150	T. B. M. 149.	775	149.959	Dir ...	− 546.80	+0.70	+6.35	−6.35	0.47	7.7	+3.50	163.32489	535.848			W.
				Rev...	− 545.40	−0.70										
				Mean .	− 546.10											
*P. B. M. 44	T. B. M. 150.	608	150.567	Dir ...	+ 176.10	+0.65	+7.00	−7.00	0.43	7.7	+3.52	163.50166	536.428			F
				Rev...	+ 177.40	−0.65										
				Mean .	+ 176.75											
T. B. M. 151	T. B. M. 150.	1,053	151.012	Dir ...	+ 132.30	−0.70	+5.65	−5.65	0.47	7.7	+3.52	163.45651	536.279			F.
				Rev...	+ 130.90	+0.70										
				Mean .	+ 131.60											
T. B. M. 152 Mallard Creek.	T. B. M. 151.	942	151.954	Dir ...	+ 1,120.70	−0.35	+5.30	−5.30	0.23	7.7	+3.67	164.57701	539.956			F.
				Rev...	+ 1,120.00	+0.35										
				Mean .	+ 1,120.35											

T. B. M. 153	T. B. M. 152.	951	152.905	Dir	— 266.20	+0.20	+5.50	−5.50	0.13	7.7	+3.63	164.31097	539.083		W.
				Rev.	— 265.80	−0.20									
				Mean	— 266.00										
T. B. M. 154	*T. B. M. 153.*	*1,036*	*153.941*	Dir	+ 563.30	+0.45	+5.95	−5.95	0.30	7.7	+3.71	164.87480	540.933		W.
				Rev.	+ 564.20	−0.45									
				Mean	+ 563.75										
T. B. M. 155	T. B. M. 154.	968	154.909	Dir	+ 858.50	+1.60	+7.55	−7.55	1.07	7.8	+3.82	165.73501	543.755		F.
				Rev.	+ 861.70	−1.60									
				Mean	+ 860.10										
T. B. M. 156	T. B. M. 155.	1,064	155.973	Dir	— 2,419.80	+1.00	+8.55	−8.55	0.67	7.8	+3.50	163.31589	535.818		F.
				Rev.	— 2,417.80	−1.00									
				Mean	— 2,418.80										
*P. B. M. 45 Browns Ferry.	T. B. M. 156.	220	156.193	Dir	+ 1,700.00	+0.05	+8.60	−8.60	0.03	7.8	+3.73	165.01617	541.396		F.
				Rev.	+ 1,700.10	−0.05									
				Mean	+ 1,700.05										
*P. B. M. 46	T. B. M. 156.	277	156.250	Dir	+ 1,915.70	0.00	+8.55	−8.55	0.00	7.8	+3.75	165.23184	542.104		F.
				Rev.	+ 1,915.70	0.00									
				Mean	+ 1,915.70										
T. B. M. 157	T. B. M. 156.	706	156.679	Dir	+ 2,101.90	−1.20	+7.35	−7.35	0.80	7.8	+3.78	165.41687	542.711		W.
				Rev.	+ 2,099.50	+1.20									
				Mean	+ 2,100.70										
T. B. M. 158	T. B. M. 157.	507	157.186	Dir	+ 145.60	−0.50	+6.85	−6.85	0.33	7.9	+3.80	165.56199	543.187		W.
				Rev.	+ 144.60	+0.50									
				Mean	+ 145.10										
T. B. M. 159	T. B. M. 158.	560	157.746	Dir	+ 361.20	+0.40	+7.25	−7.25	0.27	7.9	+3.85	165.92364	544.374		W.
				Rev.	+ 362.00	−0.40									
				Mean	+ 361.60										
T. B. M. 160 Foxes Creek.	T. B. M. 159.	589	158.335	1 Dir.	— 549.00	+3.20	+8.20	−8.20	0.73	7.9	+3.78	165.37777	542.583		W.
				1 Rev.	— 545.30	−0.50									
				2 Dir.	— 544.50	−1.30									
				2 Rev.	— 544.40	−1.40									
				Mean	— 545.80										

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod corrections.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 161	T. B. M. 160	1,184	159.519	Dir...	— 76.80	—1.75	+6.45	—6.45	1.17	8.0	+3.77	165.29921	542.325			F.
				Rev...	— 80.30	+1.75										
				Mean.	— 78.55											
T. B. M. 162	T. B. M. 161	1,126	160.645	Dir...	+ 1,597.40	—0.65	+5.80	—5.80	0.43	8.0	+3.99	166.89618	547.565			F.
				Rev...	+ 1,596.10	+0.65										
				Mean.	+ 1,596.75											
T. B. M. 163	T. B. M. 162	845	161.490	Dir...	— 523.30	—1.15	+4.65	—4.65	0.77	8.1	+3.92	166.37166	545.844			W.
				Rev...	— 525.60	+1.15										
				Mean.	— 524.45											
T. B. M. 164	T. B. M. 163	858	162.348	Dir...	— 813.20	—0.05	+4.60	—4.60	0.03	8.1	+3.80	165.55829	543.175			W.
				Rev...	— 813.30	+0.05										
				Mean.	— 813.25											
T. B. M. 165	T. B. M. 164	585	162.933	Dir...	— 118.20	—0.20	+4.40	—4.40	0.13	8.1	+3.78	165.43987	542.787			F.
				Rev...	— 118.60	+0.20										
				Mean.	— 118.40											
T. B. M. 166	T. B. M. 165	464	163.397	1 Dir..	— 135.40	—1.60	+3.40	—3.40	0.55	8.1	+3.77	165.30286	542.337			F.
				1 Rev.	— 139.40	+2.40										
				2 Dir..	— 136.60	—0.40										
				2 Rev.	— 136.60	—0.40										
				Mean.	— 137.00											
T. B. M. 167	T. B. M. 166	694	164.091	Dir...	+ 1,749.60	—0.35	+3.05	—3.05	0.23	8.1	+4.00	167.05234	548.077			F.
				Rev...	+ 1,748.90	+0.35										
				Mean.	+ 1,749.25											
T. B. M. 168 Finleys Landing.	T. B. M. 167	835	164.926	Dir...	— 1,418.50	—0.25	+2.80	—2.80	0.17	8.1	+3.81	165.63340	543.422			W.
				Rev...	— 1,419.00	+0.25										
				Mean.	— 1,418.75											

*P. B. M. 47	T. B. M. 168	154	165.080	Dir ...	+ 419.10	+0.40	+3.20	—3.20	0.27	8.1	+3.86	166.05295	544.788			W
				Rev...	+ 419.90	—0.40										
				Mean .	+ 419.50											
T. B. M. 169	T. B. M. 168	1,005	165.931	1 Dir..	+ 1,196.20†	+7.67	+2.03	—2.03	0.49	8.1	+3.97	166.83743	547.372			W.
				1 Rev .	+ 1,201.90	+1.97										
				2 Dir..	+ 1,204.90	—1.03										
				2 Rev .	+ 1,204.80	—0.93										
				Mean .	+ 1,203.87											
T. B. M. 170	T. B. M. 169	1,368	167.299	Dir ...	+ 869.90	—0.30	+1.73	—1.73	0.20	8.1	+4.09	167.70715	550.225			F.
				Rev...	+ 869.30	+0.30										
				Mean .	+ 869.60											
T. B. M. 171	T. B. M. 170	982	168.281	Dir ...	— 487.60	—0.35	+1.38	—1.38	0.23	8.1	+4.02	167.21913	548.624			F.
				Rev...	— 488.30	+0.35										
				Mean .	— 487.95											
T. B. M. 172	T. B. M. 171	852	169.133	Dir ...	— 2,851.30	—0.25	+1.13	—1.13	0.17	8.1	+3.64	164.36720	539.267			W.
				Rev...	— 2,851.80	+0.25										
				Mean .	— 2,851.55											
T. B. M. 173	T. B. M. 172	822	169.955	1 Dir..	+ 635.00	—3.42	—0.19	+0.19	0.81	8.1	+3.73	164.99887	541.340			W.
				1 Rev .	+ 631.20	+0.38										
				2 Dir..	+ 630.80	+0.78										
				2 Rev .	+ 629.30	+2.28										
				Mean .	+ 631.58											
T. B. M. 174	T. B. M. 173	872	170.827	Dir ...	+ 457.40	+0.60	+0.41	—0.41	0.40	8.2	+3.79	165.45693	542.843			F.
				Rev ..	+ 458.60	—0.60										
				Mean .	+ 458.00											
T. B. M. 175	T. B. M. 174	637	171.464	Dir ...	— 450.40	—0.35	+0.06	—0.06	0.23	8.2	+3.73	165.00612	541.361			F.
				Rev...	— 451.10	+0.35										
				Mean .	— 450.75											
T. B. M. 176	T. B. M. 175	175	171.639	Dir ...	— 1,986.00	+0.15	+0.21	—0.21	0.10	8.2	+3.46	163.02000	534.847			F.
				Rev...	— 1,985.70	—0.15										
				Mean .	— 1,985.85											

Tabulation of precise-level results, 1895, from Corinth, Miss., to Decatur, Ala.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V.		r. ±	R. ±	Red corrections.	Elevation above mean Gulf level, Biloxi.			Correction.	Observer.
							Direct line.	Reverse line.				Meters.	Feet.	Former by common level.		
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
* P. B. M. 48	T. B. M. 176	36	171.675	Dir ...	+ 769.80	+0.05	+0.26	−0.26	0.03	8.2	+3.56	163.78995	537.373	.....	.....	F.
				Rev...	+ 769.90	−0.05										
				Mean .	+ 769.85											
T. B. M. 177	T. B. M. 176	683	172.322	Dir ...	+ 1,257.50	−0.05	+0.16	−0.16	0.03	8.2	+3.63	164.27762	538.973	.....	.....	F.
				Rev...	+ 1,257.40	+0.05										
				Mean .	+ 1,257.45											
* P. B. M. 49	T. B. M. 177	114	172.436	Dir ...	+ 1,603.70	−0.40	−0.24	+0.24	0.27	8.2	+3.85	165.88114	544.234	.....	.....	F.
				Rev...	+ 1,602.90	+0.40										
				Mean .	+ 1,603.30											
* Zero of gauge	T. B. M. 177	394	172.716	Dir ...	− 2,735.30	−1.10	−0.94	+0.94	0.73	8.2	+3.73	161.54132	529.996	537.71	−7.714	F.
				Rev...	− 2,737.50	+1.10										
				Mean .	− 2,736.40											
* P. B. M. 50 Decatur.	T. B. M. 177	269	172.591	Dir ...	+ 4,076.70	+0.15	+0.31	−0.31	0.10	8.2	+4.17	168.35501	552.351	.....	.....	F.
				Rev...	+ 4,077.00	−0.15										
				Mean .	+ 4,076.86											
Old B. M. "U X S"	T. B. M. 177	295	172.617	Dir ...	+ 7,507.60	+0.10	+0.26	−0.26	0.07	8.2	+4.64	171.78633	563.608	571.37	−7.762	F.
				Rev...	+ 7,507.80	−0.10										
				Mean .	+ 7,507.70											
* Old R. R. B. M.	"U X S"	42	172.659	Dir ...	+ 230.30	0.00	+0.26	−0.26	0.00	8.2	+4.67	172.01666	564.364	564.99	−0.626	F.
				Rev...	+ 230.30	0.00										
				Mean .	+ 230.30											
* P. B. M. 51	"U X S"	22	172.639	Dir ...	− 616.30	+0.10	+0.36	−0.36	0.07	8.2	+4.56	171.17005	561.587	.....	.....	W.
				Rev...	− 616.10	−0.10										
				Mean .	− 616.20											

P. B. M. 52	"U X S"	472	173.089	Dir Rev Mean	+ 168.90 + 166.20 + 167.55	—1.35 +1.35	—1.09	+1.09	0.90	8.2	+4.66	171.95390	564.158			W.

Tabulation of precise-level results, 1895, from Riverton, Ala., to 4 miles below Pittsburg Landing, Tenn.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V.		r. ±	R. ±	Rod correction.	Elevation above mean Gulf level, Biloxi.			Correction.	Observer.
							Direct line.	Reverse line.				Meters.	Feet.	Former by common level.		
Riverton Junction.		*Meters.*	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. A	T. B. M. 44	948	49.541	Dir Rev Mean	+ 1,579.10 + 1,580.90 + 1,580.00	+0.90 —0.90	—2.65	+2.65	0.60	3.8	—1.32	127.60304	418.649			W.
T. B. M. B	T. B. M. A	1,536	51.077	Dir Rev Mean	— 1,094.30 — 1,096.70 — 1,095.50	—1.20 +1.20	—3.85	+3.85	0.80	3.8	—1.47	126.50739	415.054			W.
T. B. M. C	T. B. M. B	1,506	52.583	Dir Rev Mean	— 2,022.60 — 2,024.90 — 2,023.75	—1.15 +1.15	—5.00	+5.00	0.77	3.9	—1.74	124.48337	408.414			F.
T. B. M. D	T. B. M. C	745	53.328	1 Dir 1 Rev 2 Dir 2 Rev Mean	+ 327.30 + 330.90 + 332.70 + 330.70 + 330.40	+3.10 —0.50 —2.30 —0.30	—4.60	+4.60	0.77	3.9	—1.70	124.81381	409.498			F.
T. B. M. E	T. B. M. D	889	54.217	1 Dir 1 Rev 2 Dir 2 Rev Mean	+ 8,470.00 + 8,474.70 + 8,474.50 + 8,473.10 + 8,473.08	+3.08 —1.62 —1.42 —0.02	—3.78	+3.78	0.72	4.0	—0.55	133.28804	437.301			W.

Tabulation of precise-level results, 1895, from Riverton, Ala., to 4 miles below Pittsburg Landing, Tenn.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod correction.	Elevation above mean Gulf level, Biloxi. Meters.	Feet.	Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. F	T. B. M. E	780	54.997	Dir	— 3,696.80	—0.45	—4.23	+4.23	0.30	4.1	—1.05	129.59029	425.169			W.
				Rev	— 3,697.70	+0.45										
				Mean	— 3,697.25											
T. B. M. G	T. B. M. F	1,232	56.229	Dir	— 2,336.30	—0.70	—4.93	+4.93	0.47	4.1	—1.37	127.25297	417.500			F.
				Rev.	— 2,337.70	+0.70										
				Mean	— 2,337.00											
T. B. M. H	T. B. M. G	1,036	57.265	Dir	+ 923.60	—0.40	—5.33	+5.33	0.27	4.1	—1.24	128.17630	420.530			F.
				Rev	+ 922.80	+0.40										
				Mean	+ 923.20											
T. B. M. I	T. B. M. H	913	58.178	Dir	— 1,930.50	+1.25	—4.08	+4.08	0.83	4.1	—1.51	126.24678	414.199			W.
				Rev	— 1,928.00	—1.25										
				Mean	— 1,929.25											
T. B. M. J	T. B. M. I	892	59.070	Dir	— 2,193.20	—1.00	—5.08	+5.08	0.67	4.2	—1.80	124.05229	406.999			W.
				Rev	— 2,195.20	+1.00										
				Mean	— 2,194.20											
T. B. M. K	T. B. M. J	858	59.928	Dir	— 533.50	+1.70	—3.38	+3.38	1.13	4.4	—1.88	123.52041	405.254			F.
				Rev	— 530.10	—1.70										
				Mean	— 531.80											
T. B. M. L	T. B. M. K	1,401	61.329	Dir	+ 494.60	—0.45	—3.83	+3.83	0.30	4.4	—1.81	124.01463	406.876			F.
				Rev	+ 493.70	+0.45										
				Mean	+ 494.15											
T. B. M. M	T. B. M. L	1,422	62.751	Dir	+ 873.20	+0.10	—3.73	+3.73	0.07	4.4	—1.69	124.88805	409.741			W.
				Rev	+ 873.40	—0.10										
				Mean	+ 873.30											

T. B. M. N	T. B. M. M	1,238	63.989	Dir	+ 3,537.30	+0.45	—3.28	+3.28	0.30	4.4	—1.22	128.42627	421.350			W.
				Rev	+ 3,538.20	—0.45										
				Mean	+ 3,537.75											
T. B. M. O	T. B. M. N	1,021	65.010	Dir	— 4,756.50	+1.00	—2.28	+2.28	0.67	4.4	—1.85	123.67014	405.746			F.
				Rev	— 4,754.50	—1.00										
				Mean	— 4,755.50											
T. B. M. P	T. B. M. O	434	65.444	1 Dir	— 2,717.80	+0.60	—2.48	+2.48	0.30	4.5	—2.21	120.95258	396.830			F.
				1 Rev	— 2,716.70	—0.50										F.
				2 Dir	— 2,716.20	—1.00										W.
				2 Rev	— 2,718.10	+0.90										W.
				Mean	— 2,717.20											
P. B. M. 4 Riverton.	T. B. M. P	18	65.462	1 Dir. *a*	— 128.60†	—0.52	—2.40	+2.40	0.03	4.5	—2.24	120.82343	396.406			F.
				1 Rev. *a*	— 128.30†	—0.82										F.
				2 Dir. *b*	— 129.20	+0.08										N.
				2 Rev. *b*	— 129.00	—0.12										N.
				3 Dir. *b*	— 129.20	+0.08										W.
				3 Rev. *b*	— 129.10	—0.02										W.
				Mean	— 129.12											
*T. B. M. Q=old B. M. Lift Lock.	T. B. M. P	952	66.396	Dir	— 1,195.40	—0.35	—2.75	+2.75	0.23	4.5	—2.38	119.75666	392.906			W.
				Rev	— 1,196.10	+0.35										
				Mean	— 1,195.75											
*Center Stone, No. 3.	T. B. M. Q	963	67.359	Dir	— 2,407.80	+0.10	—2.65	+2.65	0.07	4.5	—2.71	117.34863	385.006	35.143	+349.863	W.
				Rev	— 2,407.60	—0.10										
				Mean	— 2,407.70											
*Zero of Gauge No. 4.	Center stone No. 3.	278	67.637	Dir	— 7,754.80						—3.71	109.59283	359.560			F.
*P. B. M. 5=Gauge B. M.	Center stone No. 3.	287	67.646	Dir	+ 7,663.20	—0.95	—3.60	+3.60	0.63	4.5	—1.67	125.01192	410.148			W.
				Rev	+ 7,661.30	+0.95										
				Mean	+ 7,662.25											
*P. B. M. 6	P. B. M. 5	925	68.571	Dir	+ 2,375.30	+0.80	—2.80	+2.80	0.53	4.6	—1.35	127.38834	417.945			F.
				Rev	+ 2,376.90	—0.80										
				Mean	+ 2,376.10											

a May 16. *b* July 8.

Tabulation of precise-level results, 1895, from Riverton, Ala., to 4 miles below Pittsburg Landing, Tenn.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod correction.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 178	P. B. M. 4	733	66.195	Dir	— 2,563.10	+0.10	—2.30	+2.30	0.07	4.5	—2.58	118.26009	387.996			N.
				Rev	— 2,562.90	—0.10										
				Mean	— 2,563.00											
*Old B. M. 2 of 1894	T. B. M. 178	17	66.212	Dir	+ 82.30						—2.57	118.34240	388.266	238.398	+149.868	W.
T. B. M. 179 Big Bear River.	T. B. M. 178	919	67.114	Dir	+ 12.50	—0.20	—2.50	+2.50	0.13	4.5	—2.58	118.27239	388.036			W.
				Rev	+ 12.10	+0.20										
				Mean	+ 12.30											
*Old B. M. 3 of 1894 Eastport.	T. B. M. 179	96	67.210	Dir	— 5,691.70	+0.45	—2.05	+2.05	0.30	4.5	—3.35	112.58037	369.361	219.483	+149.878	F.
				Rev	— 5,690.80	—0.45										
				Mean	— 5,691.25											
T. B. M. 180	T. B. M. 179	647	67.761	Dir	— 2,535.80	+0.40	—2.10	+2.10	0.27	4.5	—2.93	115.73664	379.717			W.
				Rev	— 2,535.00	—0.40										
				Mean	— 2,535.40											
*P. B. M. 53	T. B. M. 180	853	68.614	Dir	+ 6,405.50	+0.20	—1.90	+1.90	0.13	4.5	—2.06	122.14321	400.736			F.
				Rev	+ 6,405.90	—0.20										
				Mean	+ 6,405.70											
T. B. M. 181	T. B. M. 180	687	68.448	Dir	+ 2,321.10	—0.80	—2.90	+2.90	0.53	4.5	—2.61	118.05726	387.330			N.
				Rev	+ 2,319.50	+0.80										
				Mean	+ 2,320.30											
T. B. M. 182	T. B. M. 181	798	69.246	1 Dir	+ 741.70†	—5.45	—3.05	+3.05	0.10	4.5	—2.51	118.79361	389.746	389.734	+0.012	N.
				1 Rev	+ 727.50†	+8.75										
				2 Dir	+ 736.40	—0.15										
				2 Rev	+ 736.10	+0.15										
				Mean	+ 736.25											

T. B. M. 183	T. B. M. 182.	568	69.814	1 Dir..	+ 1,221.60	+4.18	—2.53	+2.53	0.37	4.5	—2.35	120.01955	393.768			W.
				1 Rev.	+ 1,225.50	+0.28										
				2 Dir..	+ 1,224.20	+1.58										
				2 Rev.	+ 1,227.60	—1.82										
				3 Dir..	+ 1,226.10	—0.32										
				3 Rev.	+ 1,225.50	+0.28										
				Mean.	+ 1,225.78											
T. B. M. 184. Paynes Landing.	T. B. M. 183.	606	70.420	Dir ...	+ 93.80	+1.25	—1.28	+1.28	0.83	4.6	—2.33	120.11462	394.080			W.
				Rev...	+ 96.30	—1.25										
				Mean.	+ 95.05											
T. B. M. 185	T. B. M. 184.	730	71.150	Dir ...	— 630.00	+1.40	+0.12	—0.12	0.93	4.7	—2.42	119.48593	392.018			W.
				Rev...	— 627.20	—1.40										
				Mean.	— 628.60											
*Old B. M. 7 of 1894..	T. B. M. 185.	89	71.239	Dir ...	— 264.30	+0.05	+0.17	—0.17	0.03	4.7	—2.46	119.22164	391.151	241.208	+149.943	W.
				Rev...	— 264.20	—0.05										
				Mean.	— 264.25											
*P. B. M. 54	T. B. M. 185.	588	71.738	Dir ...	+ 821.70	+0.65	+0.77	—0.77	0.43	4.7	—2.31	120.30839	394.716			W.
				Rev...	+ 823.00	—0.65										
				Mean.	+ 822.35											
T. B. M. 186	T. B. M. 185.	890	72.040	Dir ...	— 2,540.30	—1.40	—1.28	+1.28	0.93	4.8	—2.77	116.94388	383.678			F.
				Rev...	— 2,543.10	+1.40										
				Mean.	— 2,541.70											
*Old B. M. 8 of 1894..	T. B. M. 186.	319	72.359	Dir ...	— 901.70	0.00	—1.28	+1.28	0.00	4.8	—2.89	116.04206	380.719	230.736	+149.983	F.
				Rev...	— 901.70	0.00										
				Mean.	— 901.70											
T. B. M. 187	T. B. M. 186.	830	72.870	Dir ...	+ 1,482.70	—0.75	—2.03	+2.03	0.50	4.8	—2.56	118.42604	388.540			F.
				Rev ..	+ 1,481.20	+0.75										
				Mean.	+ 1,481.95											
T. B. M. 188	T. B. M. 187.	836	73.706	Dir ...	+ 1,476.70	+0.50	—1.53	+1.53	0.33	4.8	—2.36	119.90344	393.388			F.
				Rev ..	+ 1,477.70	—0.50										
				Mean.	+ 1,477.20											

Tabulation of precise-level results, 1895, from Riverton, Ala., to 4 miles below Pittsburg Landing, Tenn.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V.		r. ±	R. ±	Rod correction.	Elevation above mean Gulf level, Biloxi.			Correction.	Observer.
							Direct line.	Reverse line.				Meters.	Feet.	Former by common level.		
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
P. B. M. 55 Indian Creek.	T. B. M. 188.	412	74.118	Dir ...	+ 5,293.20	—1.15	—2.68	+2.68	0.77	4.9	—1.65	125.19620	410.752	.....	.....	F.
				Rev ..	+ 5,290.90	+1.15										
				Mean .	+ 5,292.05											
T. B. M. 189	T. B. M. 188.	647	74.353	Dir ...	— 2,177.30	—1.00	—2.53	+2.53	0.67	4.9	—2.66	117.72484	386.240	.....	.....	W.
				Rev ..	— 2,179.30	+1.00										
				Mean .	— 2,178.30											
*Old B. M. 10 of 1894	T. B. M. 189.	144	74.497	Dir ...	— 6,365.30	+0.15	—2.38	+2.38	0.10	4.9	—3.54	111.35901	365.355	215.495	+149.860	F.
				Rev ..	— 6,364.60	—0.15										
				Mean .	— 6,364.95											
T. B. M. 190	T. B. M. 189.	559	74.912	Dir ...	+ 1,610.80	+0.60	—1.93	+1.93	0.40	4.9	—2.44	119.33646	391.527	.....	.....	W.
				Rev ..	+ 1,612.00	—0.60										
				Mean .	+ 1,611.40											
T. B. M. 191	T. B. M. 190.	976	75.888	Dir ...	— 1,419.60	+0.35	—1.58	+1.58	0.23	4.9	—2.63	117.91702	386.870	.....	.....	W.
				Rev ..	— 1,418.90	—0.35										
				Mean .	— 1,419.25											
T. B. M. 192	T. B. M. 191.	1,425	77.313	Dir ...	— 534.20	+0.05	—1.53	+1.53	0.03	4.9	—2.70	117.38280	385.118	.....	.....	F.
				Rev ..	— 534.10	—0.05										
				Mean .	— 534.15											
*P. B. M. 56	T. B. M. 192.	281	77.594	Dir ...	— 5,377.90	—0.55	—2.08	+2.08	0.37	4.9	—3.43	112.00362	367.469	.....	.....	F.
				Rev ..	— 5,379.00	+0.55										
				Mean .	— 5,378.45											
*Old B. M. 13 of 1894.	T. B. M. 192.	42	77.355	Dir ...	— 2,909.20	+0.35	—1.18	+1.18	0.23	4.9	—3.09	114.47356	375.573	225.709	+149.864	F.
				Rev...	— 2,908.50	—0.35										
				Mean .	— 2,908.85											

T. B. M. 193 ..... Robinsons Landing.	T. B. M. 192 .	938	78.251	Dir ...	+ 1,866.90	+0.80	—0.73	+0.73	0.53	4.9	—2.45	119.25075	391.246	.....	.....	F.
				Rev...	+ 1,868.50	—0.80										
				Mean .	+ 1,867.70											
*Old B. M. 14 of 1894.	T. B. M. 193 .	118	78.369	Dir ...	— 91.10	—0.25	—0.98	+0.98	0.17	4.9	—2.46	119.15939	390.946	241.066	+149.880	W.
				Rev...	— 91.60	+0.25										
				Mean .	— 91.35											
T. B. M. 194	T. B. M. 193 .	969	79.220	1 Dir ..	— 2,268.10	—1.28	—1.65	+1.65	0.57	4.9	—2.75	116.98107	383.800	.....	.....	W.
				1 Rev .	— 2,271.90	+2.52										
				2 Dir ..	— 2,268.80	—0.58										
				2 Rev .	— 2,268.70	—0.68										
				Mean .	— 2,269.38											
*P. B. M. 57	T. B. M. 194 .	530	79.750	Dir ...	— 140.80	+0.45	—1.20	+1.20	0.30	4.9	—2.78	116.84069	383.339	.....	.....	W.
				Rev...	— 139.90	—0.45										
				Mean .	— 140.35											
T. B. M. 195	T. B. M. 194 .	504	79.724	Dir ...	+ 541.00	—0.05	—1.70	+1.70	0.03	4.9	—2.69	117.52208	385.575	.....	.....	W.
				Rev...	+ 540.90	+0.05										
				Mean .	+ 540.95											
T. B. M. 196 ..... Hubbards Landing.	T. B. M. 195 .	969	80.693	Dir ...	+ 2,395.70	—0.60	—2.30	+2.30	0.40	5.0	—2.36	119.91751	393.434	.....	.....	F.
				Rev...	+ 2,394.50	+0.60										
				Mean .	+ 2,395.10											
* Old B. M. 16 of 1894.	T. B. M. 196 .	169	80.862	Dir ...	— 1,118.30	—0.40	—2.70	+2.70	0.27	5.0	—2.51	118.79866	389.763	239.865	+149.898	F.
				Rev...	— 1,119.10	+0.40										
				Mean .	— 1,118.70											
Old B. M. 17 of 1894...	T. B. M. 196 .	733	81.426	Dir ...	— 272.50	+0.90	—1.40	+1.40	0.60	5.0	—2.40	119.64587	392.542	242.638	+149.904	F.
				Rev...	— 270.70	—0.90										
				Mean .	— 271.60											
T. B. M. 197.....	Old B. M. 17.	935	82.361	Dir ...	— 1,839.80	+1.55	+0.15	—0.15	1.03	5.1	—2.65	117.80757	386.511	.....	.....	F.
				Rev...	— 1,836.70	—1.55										
				Mean .	— 1,838.25											
* P. B. M. 58.....	T. B. M. 197.	512	82.873	Dir ...	+ 5,106.80	+0.10	+0.25	—0.25	0.07	5.1	—1.96	122.91496	403.268	.....	.....	F.
				Rev...	+ 5,107.00	—0.10										
				Mean .	+ 5,106.90											

Tabulation of precise-level results, 1895, from Riverton, Ala., to 4 miles below Pittsburg Landing, Tenn.—Continued.

Bench mark.	Determined from--	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V.		r. ±	R. ±	Rod correction.	Elevation above mean Gulf level, Biloxi.			Correction.	Observer.
							Direct line.	Reverse line.				Meters.	Feet.	Former by common level.		
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 198..... Yellow Creek.	T. B. M. 197.	606	82.967	Dir ...	— 957.60	—0.70	—0.55	+0.55	0.47	5.1	—2.77	116.84895	383.366	.....	.....	W.
				Rev...	— 959.00	+0.70										
				Mean .	— 958.30											
* Old B. M. 20 of 1894.	T. B. M. 198.	262	83.229	Dir ...	— 5,002.60	—0.05	—0.60	+0.60	0.03	5.1	—3.47	111.84560	366.951	217.036	+149.915	W.
				Rev...	— 5,002.70	+0.05										
				Mean .	— 5,002.65											
T. B. M. 199.....	T. B. M. 198.	430	83.397	Dir ...	+ 1,517.00	—0.25	—0.80	+0.80	0.17	5.1	—2.58	118.36589	388.343	.....	.....	W.
				Rev...	+ 1,516.50	+0.25										
				Mean .	+ 1,516.75											
T. B. M. 200.....	T. B. M. 199.	754	84.151	Dir ...	— 949.40	—1.40	—2.20	+2.20	0.93	5.2	—2.71	117.41496	385.223	.....	.....	W.
				Rev...	— 952.20	+1.40										
				Mean .	— 950.80											
T. B. M. 201.....	T. B. M. 200.	866	85.017	Dir ...	+ 821.60	+1.25	—0.95	+0.95	0.83	5.3	—2.61	118.23791	387.923	.....	.....	F.
				Rev...	+ 824.10	—1.25										
				Mean .	+ 822.85											
T. B. M. 202..... Winn Spring.	T. B. M. 201.	282	85.299	Dir ...	— 1,001.10	—0.10	—1.05	+1.05	0.07	5.3	—2.74	117.23658	384.638	.....	.....	F.
				Rev...	— 1,001.30	+0.10										
				Mean .	— 1,001.20											
* P. B. M. 59.....	T. B. M. 202.	273	85.572	Dir ...	— 5,864.50	—0.40	—1.45	+1.45	0.27	5.3	—3.52	111.37090	365.393	.....	.....	F.
				Rev...	— 5,865.30	+0.40										
				Mean .	— 5,864.90											
T. B. M. 203	T. B. M. 202 .	698	85.997	Dir ...	+ 923.00	+0.95	—0.10	+0.10	0.63	5.3	—2.61	118.16066	387.670	.....	.....	W.
				Rev...	+ 924.90	—0.95										
				Mean .	+ 923.95											

T. B. M. 204	T. B. M. 203	822	86.819	1 Dir..	+ 388.30	—0.65	—0 85	+0.85	0.72	5.4	—2.55	118.54837	388.942			W
				1 Rev .	+ 384.50	+3.15										
				2 Dir..	+ 388.50	—0.85										
				2 Rev .	+ 389.30	—1.65										
				Mean .	+ 387.65											
T. B. M. 205	T. B. M. 204	894	87.713	Dir ...	+ 550.40	+0.10	—0.75	+0.75	0.07	5.4	—2.48	119.09894	390.748			F.
				Rev...	+ 550.60	—0.10										
				Mean .	+ 550.50											
* Old B. M. 24 of 1894..	T. B. M. 205	417	88130	Dir ...	— 5,558.10	—0.20	—0.55	+0.55	0.13	5.4	—3.24	113.53988	372.509	222.537	+ 149.972	F.
				Rev...	— 5,558.50	+0.20	.....	.....	.....	.....	.....	.....	.....	372.153	+ 0.356	
				Mean .	— 5,558.30											
T. B. M. 206	T. B. M. 205	1,245	88.958	Dir ...	+ 10.10	—0.65	—1.40	+1.40	0.43	5.4	—2.48	119.10839	390.779			F.
				Rev...	+ 8.80	+0.65										
				Mean .	+ 9.45											
T. B. M. 207 Boyds Landing.	T. B. M. 206	843	89.801	Dir ...	— 2,354.50	+1.50	+0.10	—0.10	1.00	5.5	—2.80	116.75507	383.058			W.
				Rev...	— 2,351.50	—1.50										
				Mean .	— 2,353.00											
* Old B. M. 26 of 1894..	T. B. M. 207	410	90.211	Dir ...	— 2,979.80	+1.15	+1.25	—1.25	0.77	5.5	—3.20	113.77602	373.284	223.330	+149.954	W.
				Rev...	— 2,977.50	—1.15										
				Mean .	— 2,978.65											
T. B. M. 208	T. B. M. 207	825	90.626	Dir ...	— 1,317.70	+0.25	+0.35	—0.35	0.17	5.5	—2.98	115.43744	378.735			F.
				Rev...	— 1,317.20	—0.25										
				Mean .	— 1,317.45											
* P. B. M. 60	T. B. M. 208	1,022	91.648	Dir ...	+ 5,830.10	+0.25	+0.60	—0.60	0.17	5.5	—2.19	121.26858	397.866			F.
				Rev...	+ 5,830.60	—0.25										
				Mean .	+ 5,830.35											
T. B. M. 209	T. B. M. 208	457	91.086	1 Dir..	+ 1,110.40	—2.68	—0.33	+0.33	0.61	5.5	—2.83	116.54531	382.370			F.
				1 Rev .	+ 1,106.90	+0.82										
				2 Dir..	+ 1,106.40	+1.32										
				2 Rev .	+ 1,107.20	+0.52										
				Mean .	+ 1,107.72											

Tabulation of precise-level results, 1895, from Riverton, Ala., to 4 miles below Pittsburg Landing, Tenn.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod correction.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 210 and A...	T. B. M. 209.	590	91.673	Dir ...	+ 135.30	—0.65	—0.98	+0.98	0.43	5.5	—2.81	116.67998	382.812	.....	.....	F.
				Rev...	+ 134.00	+0.65										
				Mean .	+ 134.65											
T. B. M. 211.....	T. B. M. 210 and A.	880	92.553	Dir ...	+ 436.90	—1.30	—2.28	+2.28	0.87	5.6	—2.75	117.11564	384.241	.....	.....	W.
				Rev...	+ 434.30	+1.30										
				Mean .	+ 435.60											
T. B. M. 212.....	T. B. M. 211	377	92.930	1 Dir..	+ 1,063.30	—1.05	—2.93	+2.93	0.43	5.6	—2.61	118.17803	387.727	.....	.....	W.
				1 Rev .	+ 1,060.40	+1.85										
				2 Dir..	+ 1,062.50	—0.25										
				2 Rev .	+ 1,062.80	—0.55										
				Mean .	+ 1,062.25											
T. B. M. 213.....	T. B. M. 212.	636	93.566	Dir ...	— 4,048.40	—0.75	—3.68	+3.68	0.50	5.6	—3.16	114.12833	374.440	.....	.....	W.
				Rev...	— 4,049.90	+0.75										
				Mean .	— 4,049.15											
*Old B. M. 30 of 1894.	T. B. M. 213.	267	93.833	Dir ...	— 2,878.20	+0.90	—2.78	+2.78	0.60	5.7	—3.54	111.25065	364.999	215.010	+149.989	W.
				Rev...	— 2,876.40	—0.90										
				Mean .	— 2,877.30											
T. B. M. 214.....	T. B. M. 213.	728	94.294	Dir ...	+ 1,909.10	—0.45	—4.13	+4.13	0.30	5.6	—2.90	116.03724	380.703	.....	.....	W.
				Rev...	+ 1,908.20	+0.45										
				Mean .	+ 1,908.65											
T. B. M. 215..... Pickwick Landing.	T. B. M. 214.	1,308	95.602	Dir ...	+ 2,563.10	+0.85	—3.28	+3.28	0.57	5.7	—2.55	118.60154	389.116	.....	.....	F.
				Rev...	+ 2,564.80	—0.85										
				Mean .	+ 2,563.95											
*Old B. M. 32 of 1894.	T. B. M. 215.	78	95.680	Dir ...	— 6,312.50	—0.15	—3.43	+3.43	0.10	5.7	—3.40	112.28804	368.402	218.416	+149.986	F.
				Rev...	— 6,312.80	+0.15										
				Mean .	— 6,312.65											

T. B. M. 216	T. B. M. 215	845	96.447	Dir	— 94.90	+0.15	—3.13	+3.13	0.10	5.7	—2.56	118.50678	388.805			F.
				Rev	— 94.60	—0.15										
				Mean	— 94.75											
T. B. M. 217 North Carolina Landing.	T. B. M. 216	964	97.411	Dir	+ 1,036.30	+1.20	—1.93	+1.93	0.80	5.7	—2.43	119.54441	392.210			W
				Rev	+ 1,038.70	—1.20										
				Mean	+ 1,037.50											
T. B. M. 218 Chambers Creek.	T. B. M. 217	929	98.340	Dir	— 2.215.70	+0.60	—1.33	+1.33	0.40	5.7	—2.73	117.32001	384.941			W.
				Rev	— 2,214.50	—0.60										
				Mean	— 2,215.10											
T. B. M. 219	T. B. M. 218	635	98.975	Dir	— 109.00	—0.35	—1.68	+1.68	0.23	5.7	—2.74	117.21965	384.582			F.
				Rev	— 109.70	+0.35										
				Mean	— 109.35											
T. B. M. 220	T. B. M. 219	570	99.545	Dir	— 228.10	+0.45	—1.23	+1.23	0.30	5.8	—2.77	116.99197	383.835			F.
				Rev	— 227.20	—0.45										
				Mean	— 227.65											
T. B. M. 221	T. B. M. 220	803	100.348	Dir	— 590.70	0.00	—1.23	+1.23	0.00	5.8	—2.85	116.40119	381.897			W.
				Rev	— 590.70	0.00										
				Mean	— 590.70											
T. B. M. 222 and A	T. B. M. 221	771	101.119	Dir	+ 487.00	+0.30	—0.93	+0.93	0.20	5.8	—2.78	116.88856	383.496			W.
				Rev	+ 487.60	—0.30										
				Mean	+ 487.30											
T. B. M. 223	T. B. M. 222 and A.	1,132	102.251	Dir	— 453.90	+0.10	—0.83	+0.83	0.07	5.8	—2.85	116.43469	382.007			F.
				Rev	— 453.70	—0.10										
				Mean	— 453.80											
T. B. M. 224	T. B. M. 223	923	103.174	Dir	— 716.30	+0.70	—0.13	+0.13	0.47	5.8	—2.94	115.71900	379.659			W.
				Rev	— 714.90	—0.70										
				Mean	— 715.60											
*Old P. B. M. 1 of 1894.	T. B. M. 224	768	103.942	Dir	— 9,761.30	—0.35	—0.48	+0.48	0.23	5.8	—4.25	105.95604	347.628	197.674	+149.954	F.
				Rev	— 9,762.00	+0.35								347.228	+ 0.400	
				Mean	— 9,761.65											

Tabulation of precise-level results, 1895, from Riverton, Ala., to 4 miles below Pittsburg Landing, Tenn.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elavation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod correction.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observor.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm*	*Mm.*				*Feet.*	
T. B. M. 225 ..... Hamburg Landing.	T. B. M. 224 .	823	103.997	Dir ...	+ 558.20	—0.45	—0.58	+0.58	0.30	5.8	—2.86	116.27683	381.489	.....	.....	F.
				Rev...	+ 557.30	+0.45										
				Mean .	+ 557.75											
* Old B. M. 0 of 1894..	T. B. M. 225 .	88	104.085	Dir ...	— 9,145.90	—0.87	—0.53	+0.53	0.34	5.8	—4.10	107.12882	351.476	201.558	+149.918	N.
				Rev...	— 9,146.70	—0.07										
				2 Dir..	— 9,147.70	+0.93										
				Mean .	— 9,146.77											
T. B. M. 226 ..... Hamburg Ferry.	T. B. M. 225 .	1,264	105.261	Dir ...	— 933.20	+0.75	+0.17	—0.17	0.50	5.8	—3.00	115.34424	378.429	.....	.....	F.
				Rev...	— 931.70	—0.75										
				Mean .	— 932.45											
* Old B. M. 1 of 1894..	T. B. M. 226 .	382	105.643	Dir ...	— 8,424.40	+0.05	+0.22	—0.22	0.03	5.8	—4.13	106.91876	350.786	200.849	+149.937	W.
				Rev...	— 8,424.30	—0.05										
				Mean .	— 8,424.35											
T. B. M. 227	T. B. M. 226 .	1,235	106.496	Dir ...	+ 1,531.20	+0.85	+1.02	—1.02	0.57	5.8	—2.78	116.87651	383.456	.....	.....	W.
				Rev...	+ 1,532.90	—0.85										
				Mean .	+ 1,532.05											
T. B. M. 228	T. B. M. 227 .	1,345	107.841	Dir ...	— 2,531.10	—1.40	—0.38	+0.38	0.93	5.9	—3.13	114.34366	375.147	.....	.....	W.
				Rev...	— 2,533.90	+1.40										
				Mean .	— 2,532.50											
T. B. M. 229 ..... Browns Ferry.	T. B. M. 228 .	1,372	109.213	Dir ...	+ 1,322.80	+0.80	+0.42	—0.42	0.53	5.9	—2.94	115.66745	379.490	.....	.....	F.
				Rev...	+ 1,324.40	—0.80										
				Mean .	+ 1,323.60											
T. B. M. 230	T. B. M. 229 .	672	109.885	Dir ...	— 1,159.40	+1.35	+1.77	—1.77	0.90	6.0	—3.10	114.50924	375.690	.....	.....	F.
				Rev...	— 1,156.70	—1.35										
				Mean .	— 1,158.05											

T. B. M. 231	T. B. M. 230	576	110.461	Dir	— 6,450.20	+1.25	+3.02	—3.02	0.83	6.1	—3.97	108.05942	354.529			W.
				Rev	— 6,447.70	—1.25										
				Mean	— 6,448.95											
Old P. B. M. 2 of 1894.	T. B. M. 231	567	111.028	Dir	+ 8,875.00	—0.20	+2.82	—2.82	0.13	6.1	—2.78	116.93541	383.650	233.713	+149.937	W
				Rev	+ 8,874.60	+0.20										
				Mean	+ 8,874.80											
*Old B. M. 3 of 1894. Pittsburg Landing.	P. B. M. 2	267	111.295	Dir	— 8,713.10	+0.10	+2.92	—2.92	0.07	6.1	—3.96	108.22123	355.060	205.146	+149.914	W.
				Rev	— 8,712.90	—0.10										
				Mean	— 8,713.00											
*P. B. M. 61	P. B. M. 2	248	111.276	Dir	+10,210.30	—0.65	+2.17	—2.17	0.43	6.1	—1.40	127.14644	417.151			N.
				Rev	+10,209.00	+0.65										
				Mean	+10,209.65											
T. B. M. 232 Snake Creek.	P. B. M. 2	748	111.776	Dir	+ 6.80	+1.30	+4.12	—4.12	0.87	6.1	—2.78	116.94351	383.676			F.
				Rev	+ 9.40	—1.30										
				Mean	+ 8.10											
T. B. M. 233	T. B. M. 232	504	112.280	Dir	— 669.10	—0.35	+3.77	—3.77	0.23	6.1	—2.86	116.27398	381.480			F.
				Rev	— 669.80	+0.35										
				Mean	— 669.45											
T. B. M. 234	T. B. M. 233	516	112.796	Dir	— 125.80	+0.30	+4.07	—4.07	0.20	6.1	—2.88	116.14846	381.068			F.
				Rev	— 125.20	—0.30										
				Mean	— 125.50											
T. B. M. 235	T. B. M. 234	944	113.740	Dir	+ 257.60	+1.90	+5.97	—5.97	1.27	6.3	—2.85	116.40799	381.919			W.
				Rev	+ 261.40	—1.90										
				Mean	+ 259.50											
T. B. M. 236	T. B. M. 235	727	114.467	Dir	— 1,052.90	—0.55	+5.42	—5.42	0.37	6.3	—2.98	115.35441	378.463			W.
				Rev	— 1,054.00	+0.55										
				Mean	— 1,053.45											
T. B. M. 237	T. B. M. 236	702	115.169	Dir	— 1,665.90	+0.30	+5.72	—5.72	0.20	6.3	—3.21	113.68858	372.997			F.
				Rev	— 1,665.30	—0.30										
				Mean	— 1,665.60											

Tabulation of precise-level results, 1895, from Riverton, Ala., to 4 miles below Pittsburg Landing, Tenn.—Continued.

Bench mark.	Determined from—	Length of stretch.	Distance from initial point.	Direction.	Difference of elevation.	Residuals=V.	Σ V. Direct line.	Σ V. Reverse line.	r. ±	R. ±	Rod correction.	Elevation above mean Gulf level, Biloxi. Meters.	Elevation above mean Gulf level, Biloxi. Feet.	Elevation above mean Gulf level, Biloxi. Former by common level.	Correction.	Observer.
		Meters.	*Km.*		*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*				*Feet.*	
T. B. M. 238	T. B. M. 237	1,419	116.588	Dir ...	— 876.50	+0.10	+5.82	—5.82	0.07	6.3	—3.33	112.81206	370.122			F.
				Rev...	— 876.30	—0.10										
				Mean .	— 876.40											
T. B. M. 239	T. B. M. 238	533	117.121	Dir ...	— 3,304.10	+0.65	+6.47	—6.47	0.43	6.3	—3.78	109.50816	359.282			W.
				Rev...	— 3,302.80	— 0.65										
				Mean .	— 3,303.45											
*Old B. M. 6 of 1894	T. B. M. 239	32	117.153	Dir ...	— 4,444.40	—0.05	+6.42	—6.42	0.03	6.3	—4.37	105.06312	344.698	194.788	+149.910	W.
				Rev...	— 4,444.50	+0.05										
				Mean .	— 4,444.45											
T. B. M. 240	T. B. M. 239	28	117.149	Dir ...	— 768.80	+0.35	+6.17	—6.17	0.23	6.3	—3.88	108.74761	356.787			W.
				Rev...	— 760.10	—0.35										
				Mean .	— 760.45											
At Corinth Junction of M. & C. and M. & O.	T. B. M. 1	383	0.420	Dir ...	— 3,994.80							132.965	436.24			
At Glens Center of platform.	T. B. M. 13	280	13.267	Dir ...	+ 1,171.50							151.026	495.50			
At Iuka Center of depot.	T. B. M. 33	236	36.383	Dir ...	+ 341.00							168.563	553.03			
At Riverton Junction. Center of depot.	T. B. M. 44	160	49.928	Dir ...	+ 1,011.00							127.034	416.78			
At Limekiln platform, 2 miles east of Riverton Junction.	T. B. M. 47	336	52.203	Dir ...	+ 2,307.50							135.838	445.67			
At Dixon Center of depot.	T. B. M. 49	686	55.244	Dir ...	+ 7,076.70							154.649	507.38			
At Cherokee Center of depot.	T. B. M. 52	143	58.500	Dir ...	— 1,500.60							156.370	513.03			
At Barton Center of depot.	T. B. M. 59	140	66.339	Dir ...	+ 84.10							145.929	478.77			

At Tuscumbia..... Center of depot.	T. B. M. 80 ..	85	85.158	Dir ...	+	64.60	.....	.....	.....	.....	.....	.....	141.597	464.56	.....	.....
Intersection B. S. & T. River Railway with M. & C.	T. B. M. 83 ..	222	88.609	Dir ...	—	596.20	.....	.....	.....	.....	.....	.....	154.910	508.24	.....	.....
At Florence ..... Center of draw M. & C. bridge.	T. B. M. 87 ..	180	92.884	Dir ...	+	1,651.00	.....	.....	.....	.....	.....	.....	137.726	451.86	.....	.....

APPENDIX C.

REPORT OF MR. G. T. NELLES, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Chattanooga, Tenn., May 17, 1896.

CAPTAIN: I respectfully submit the following report on the discharge of the Tennessee River and tributaries, based on a study of the records of this office:

The importance of a full knowledge of this question does not appear to have been recognized, consequently the observations are few and far between, and were made for some immediate or special purpose rather than for the purpose of a scientific study of the hydraulics of the river.

The records found are as follows:

Knoxville.—Observations made May 28 and October 17, 1891, by Capt. John Biddle, Corps of Engineers, United States Army, and Assistant Engineer W. L. Van Ornum. On May 28 meter observations were taken at each foot of depth at 8 points on the section, from 50 to 150 feet apart. On October 17 mid-depth velocity observations were taken by meter at 9 points on the section, about 50 feet apart, the last point being 150 feet from the bank.

Huffs Ferry.—Observations made August 1 and October 23, 1891, by Captain Biddle and Assistant Van Ornum. On August 1 meter observations were taken at each 1, 3, 5, 7, 9, etc., feet of depth, at 7 points on the section, from 75 to 150 feet apart. On October 23 mid-depth velocities were taken by meter at 15 points on the section, about 50 feet apart.

Clinch River.—Observations made October 25, 1891, by Captain Biddle and Assistant Van Ornum. Mid-depth velocities were taken by meter at 9 points on the section, from 25 to 50 feet apart.

Hiawassee River.—Observations made October 29, 1891, by Captain Biddle and Assistant Van Ornum. Mid-depth velocities were taken by meter at 13 points on the section, from 25 to 40 feet apart.

Soddy Shoals.—Observations made December 12, 1892, by direction of Captain Biddle. No record of this observation in office.

The notes relating to the above observations (except Soddy Shoals) are to be found in Notebooks Nos. 153, 155, and 156, and the results are published in the report of Captain Biddle dated January 28, 1893, Ex. Doc. 252, Fifty-second Congress, second session.

Chattanooga.—Observations made November 13, 1891, by Asst. Engineer D. L. Sublett. Velocity observations were taken by meter at each 1, 3, 5, 7, 9, etc., feet of depth at 21 points on the section, about 50 feet apart.

Observations made January 15 and 16, 1892, by Asst. Engineer D. L. Sublett. Velocity observations were taken by meter at each 1, 5, 10, 15, etc., feet of depth at 7 points on the section, from 150 to 300 feet apart.

Observations made April 11, 1892, by Asst. Engineer D. L. Sublett. Velocity observations were taken by meter at each 1, 5, 10, 15, etc., feet of depth at 6 points on the section, from 200 to 300 feet apart.

Tumbling Shoals.—Observations made October 5 and 6, 1891, by Asst. Engineer D. L. Sublett. Velocity observations were taken by meter at each 1, 3, 6, 9, etc., feet of depth, at points from 50 to 150 feet apart. On November 5, 10 points were occupied, and on November 6, 8 points.

The notes of the Chattanooga and Tumbling Shoals observations are given in Notebook No. 570. The sections and results are shown on cross-section sheets, properly marked.

Florence.—Surface-float velocity observations were made March 30 to April 4, 1888, by Lieut. H. E. Waterman, Corps of Engineers, United States Army. There is no exact record of the location of the section or of the depths. See Notebooks Nos. 608 and 609.

On September 25, 1891, an observation was made about 1 mile below Florence Bridge. The only record of this observation to be found is contained in a letter dated April 12, 1892, written by Capt. G. W. Goethals, Corps of Engineers, United States Army, to the Chief of Engineers, United States Army.

Colbert Shoals.—Observations made October, 1890, by B. B. Smith, assistant engineer. The section is shown on map of the proposed Bee Tree and Colbert Shoals Canal, made by Le Baron and Smith in 1890. The velocity in miles per hour, as well as the corresponding position of the meter, at 6 points on the section, from 150 to 300 feet apart are shown on the map.

Riverton.—Observations made October 8, 1894, by George W. Brown, assistant engineer. The velocity was taken by meter at each foot of depth at 14 points on the section, from 35 to 100 feet apart.

Duck River.—Observation made September 8, 1879, by D. L. Sublett, assistant engineer. Maximum surface velocity obtained by means of floats.

Livingston Point.—Observations made October 19, 1894, by George W. Brown, assistant engineer. At a section 6,000 feet above Livington Point, Ky., the velocity was taken by meter at each foot of depth at 10 points on the section, from 100 to 150 feet apart. The notes of the Riverton and the Livingston Point observations are given in books No. 768 and 769. They are also described and discussed in report by Mr. Brown dated December 12, 1894, and in report by myself dated April 6, 1896.

I have, so far as possible, checked the original calculations and made a careful study of all the notes. The results of these calculations, as well as others hereafter mentioned, are given in table of "discharge data" herewith submitted. My results agree with those given by Captain Biddle in his report of January 28, 1893, for the observations at Knoxville, Huffs Ferry, Clinch and Hiawassee rivers, using a coëfficient of 0.96 to reduce the mid-depth velocity observations to a mean velocity. All of Captain Biddle's sections were selected with judgment, and the observations show evidence of care. The velocities obtained are quite consistent, and may, in my opinion, be depended on in deriving the velocity relations to a much greater extent than any of the other observations of which we have a record. In deducing the velocity from Captain Biddle's observations I have used rating observations made at Muscle Shoals Canal, October 15, 1891, by Asst. Engineer W. A. McFarland, from which I have arrived at a formula for the velocity in feet per second.

$$y = 0.0627\ x + 0.042$$

in which x represents the number of revolutions per minute. Captain Biddle also made rating observations, but I can find no evidence to show which rating he used in calculating the discharge.

For the original computation of the discharge at Chattanooga and Tumbling Shoals, made by Assistant Engineer Sublett, the velocity was obtained graphically from meter-rating observations made at McFarlands Lake by Mr. W. S. Winn February 2, 1892.

The mean velocity at each observation point was taken as the mean of the observed velocities at that point, regardless of the depth or number of observations.

For my calculations the velocity was derived from the same rating, but the mathematical instead of the graphical method was used, giving the formula:

$$y = 0.061\ x + 0.152$$

in which y = velocity in feet per second and x = the number of revolutions per minute. In order to obtain the mean velocity a "velocity polygon" was constructed for each observation point, using the depths in feet as ordinates and the corresponding velocities in feet per second as the abscissæ. The area of this polygon, divided by the total depth at that point, gives the mean velocity. This mean velocity multiplied by the area of the partial section to which it applies gives the partial discharge. The sum of all the partial discharges makes the total discharge at the section.

My result was practically the same as Mr. Sublett's for the observation of November 13, 1891, but for the other observations made by Mr. Sublett my results are considerably smaller than his. At Tumbling Shoals Mr. Sublett derived the mean velocity from the maximum, using Prony's formula. I have, by combining the two observations, arrived at a result about 5 per cent in excess of his.

The first observations at Florence were made by Lieutenant Waterman, in connection with the project for the proposed Colbert and Bee Tree Shoals Canal. The following is a summary of his results:

Date.	Gauge.	Mean surface velocity $=V'$.	Maximum surface velocity.	Mean velocity $V=V'+0.5-\sqrt{v'}$
1888.				
March 30	20.17	6.992	.....	4.848
March 31	19.12	6.158	7.48	4.595
March 31	19.12	6.512	7.58	5.401
April 2	17.75	5.520	6.40	3.673
April 4	16.70	6.675	8.70	4.595

The mean surface velocity given by him is the arithmetical mean of all of the observations of that date. Judging from the Chattanooga observations, taken at about the same relative stages, the mean velocities given by Lieutenant Waterman and calculated by the formula $v=v'+0.5\ \sqrt{v'}$, in which v' is the mean surface

velocity, are entirely to small. For, by assuming the depths from recent surveys, I have obtained a cross section that can not differ materially in area from that observed by Lieutenant Waterman. Using the area of this section, with the calculated mean velocities given in preceding table, discharges are obtained which are much less than the discharge at Chattanooga for equivalent stages. However, by taking the mean velocity as 77 per cent of the mean surface velocity, which is the mean relation of the two high-water observations at Chattanooga, a discharge of 250,000 cubic feet per second is obtained for a 20-foot stage, which is about equivalent to a discharge of 240,000 cubic feet and a 35-foot stage at Chattanooga. Lieutenant Waterman in his report on the Colbert Shoals Canal project, dated February 8, 1888, gives the discharge for about this same stage, calculated by formula, as 230,000 cubic feet. Other observations have been made at Florence, but no record of same can be found except the letter of Captain Goethals before referred to, which gives the discharge for a 1.4-foot stage, as 22,444 cubic feet at a section 5,875 feet below the Florence Bridge. This result is undoubtedly wrong. When checked by formula, using a section at same point measured in 1891, and slope observed at the same time, a discharge of 12,700 cubic feet for a 1.4-foot stage is obtained. From the same data an extreme low-water discharge of 6,500 cubic feet per second is obtained. The section between Colbert and Bee Tree shoals was measured at about a 3-foot stage, in connection with the survey for the new canal, in October, 1890. The velocity was taken at about six-tenths of the depth, at 6 points in the section. The discharge obtained by using these velocities in connection with the area of section, scaled from the "Le Baron and Smith map," is 18,400 cubic feet per second. When checked by formula, results of 20,000 cubic feet per second for a 3-foot stage, and 8,000 cubic feet per second for a —0.8-foot stage are obtained.

The observations at Riverton and above Livingston Point were not worked up until recently. The results are discussed in my report to you dated April 6, 1896, from which I quote as follows: "The observations taken to rate the meter were with but two exceptions at higher velocities than any of the observed velocities at Riverton, and were in every instance higher than the observed velocities above Livingston Point." This not only made it impossible to apply the ratings directly to the observations, as is now the practice on the Mississippi River, but made it necessary to depend entirely on calculated velocities in deducing the discharge.

In reducing the rating observations (which were made by Assistant Engineer W. A. McFarland at Muscle Shoals Canal October 16, 1894) the method used by the Mississippi River Commission has been adhered to, and the following formula for the velocity in feet per second obtained:

$$y = 0.0611\,x + 0.162,$$

in which x represents the number of revolutions of the meter per minute.

The velocities obtained by this formula are lower than the velocities obtained by float observation in two instances where the meter revolved very slowly. It is to be regretted that a sufficient number of floats were not run in connection with these observations to fully establish the value of one revolution at very low velocities.

The method outlined by Mr. Brown in his report on these observations has been followed in determining the discharge. This method consists in the construction of a "velocity polygon" for each observation point, from which the mean velocity and discharge through a section 1 foot in width at the point in question are obtained. A "discharge polygon" is then constructed, using the discharge through a section 1 foot in width at each observation point as the ordinates and the distance out of each point as the abscissæ. The area of this polygon represents the total discharge. These results were checked by the usual method of partial sections, as follows:

Place.	Extreme low water.	Gauge at time of observation.	Discharge (cubic feet per second).	
			Calculated from discharge polygon.	Calculated from partial sections.
Riverton	—1.6	—0.95	10,200	10,250
Livingston Point	—0.7	+0.40	10,150	10,140

The results obtained for these two localities are discordant, in that they give a slightly greater discharge at Riverton than at Livingston Point, 220 miles below.

Both observations were taken by the same observer and with apparently the same care; it is therefore difficult to assign a reason for the discordance. It is, however, in part due to the lack of ratings at extremely low velocities, which in all probability affect the Livingston Point discharge to a greater extent than that at Riverton.

Calculations by formula indicate that the observed discharge at Livingston Point is too small, and that at Riverton is too large.

It is my opinion, however, that the slope observed and given by Mr. Brown does not correctly represent the slope at this section. From the low-water survey made in 1894 slopes are obtained for this immediate vicinity, ranging from 0.00025 to 0.0003, instead of 0.000147, as given by Mr. Brown. Using 0.000275 (a mean of the first two given), a resulting discharge of 9.200 cubic feet for a —1-foot stage, and 7.200 cubic feet for extreme low water, or a —1.7-foot stage, is obtained.

Wherever the necessary hydraulic functions could be obtained, either from direct observation or by reasonable assumption, the discharge has been calculated by means of the formula

$$v = c\sqrt{rs}.$$

The results obtained in this manner are simply approximations, and are only given for the purpose of comparison, in the absence of something more reliable.

Under the usual method of obtaining the slope it is almost, if not quite, impossible to obtain a slope that correctly represents the value to which the velocity in the section is due. This may not be possible under any method, still it is thought that the method hereafter described will give good results. The slopes I have used in my calculations are, generally speaking, mean slopes, and represent the slope for a distance of from 1 to 3 miles in the vicinity of the discharge section.

From the observations at Knoxville, May 26, 1891, and at Chattanooga, November 13, 1891, and January 15 and 16, 1892, a value of 0.034 for the coefficient of roughness, n in Kutter's formula has been deduced. These particular sections were selected because the necessary hydraulic functions were quite well defined in all of them. The value 0.034 is practically the same in the three cases. It is believed that this value is not far from the truth for that portion of the river which has a rocky bed and banks.

From a study of all the data and calculations before me I estimate the extreme low-water discharge of the Tennessee River per second as follows:

	Stage of water.	Cubic feet.
Knoxville gauge	—1.0	3,000 ±
Huffs Ferry gauge	—1.0	4,000 ±
Chattanooga gauge	0.0	7,000 ±
Florence gauge	—0.8	8,000 ±
Riverton gauge	—1.7	8,000 ±
Livingston Point gauge	—0.4	9,000 ±

The table given, showing the velocity relations, is of interest, but of no particular scientific value except possibly so far as it relates to the Knoxville, Huffs Ferry, and Riverton observations, which observations were taken with greater care, and in more detail than the others. I checked the high-water discharge at Chattanooga in April and January, 1892, by reducing the observed velocities at given depths to mean velocities by means of the factors of reduction, deduced for use on the Mississippi River from observations at Arkansas City and at Wilsons Point, with the following results:

Chattanooga.	Observed mean velocity.	Calculated mean velocity.	
		From observed velocity at 10 feet deep.	From observed velocity at 15 feet deep.
January 15 and 16, 1892	4.82	4.93	4.84
April 11, 1892	4.91	4.90	5.11

These results show a maximum variation of only 4 per cent, notwithstanding the fact that the factors used were derived from observations on a river of very different characteristics.

The Tennessee River can with reason be said to have a stable regimen, and a series of properly taken observations at characteristic sections, covering periods of stationary river at both high and low stages as well as periods at both rising and falling stages, would establish the relation between gauge and discharge and also the velocity relations in the sections considered and for the whole river.

Such a determination would form a valuable addition to existing knowledge of river hydraulics, and would aid in the solution of the problem of improving the river, by determining the proper low-water channel widths and the proper height for dams and locks.

If such a series of observations should be undertaken, I would suggest the careful determination of the slope at various points in the cross section, instead of along the bank, by means of a floating "slope rod" similar to that used on the Missouri River, and illustrated in the Annual Report of the Chief of Engineers, United States Army, for 1883, between pages 1326 and 1327.

By this means it is thought that, at least at the lower stages, the slope, as well as the velocity, could be obtained at each observation point in the section, and that the relation between the slope and the velocity might be established.

The table of "discharge data" submitted herewith gives all results obtained as well as the observed data on which the calculations were based.

The results obtained directly or indirectly from observation are separated from the results obtained by formula.

Very respectfully, your obedient servant,

G. T. NELLES.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

Discharge data, Tennessee River and tributaries.

Location of discharge section.			Date of observation.	Stage (gauge and condition).	Data and results derived from observation.								Results by formula.				Name of observer, etc.
Place.	River.	Distance above Paducah.			Area of section.	Wetted perimeter.	Hydraulic mean depth.	Slope.	Mean velocity per second.	Discharge per second.	Coefficient C, Chezy formula.	Coefficient N, Kutter formula.	Mean velocity per second.	Discharge per second.	Coefficient C.	Assumed coefficient N.	
		Miles.			*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Cu. ft.*			*Feet.*	*Cu. ft.*			
Knoxville	Tennessee	636	May 28, 1891	2.5, Knoxville, rising.	5,950	592.3	10.045	.00008	1.870	11,150	67.0	.034	1.870	11,100	67.0	.034	Capt. John Biddle and Assistant Engineer J. L. Van Ornum.
Do	do	636	Oct. 17, 1891	0.8, Knoxville, stationary.	4,960	582.2	8.519	.....	0.796	3,950	30.0	....	.....	.....	....	....	Do.
Do	do	636	Extreme low water.	—1.0, Knoxville	3,930	.....	6.700	.00008	.....	.....	....	....	1.750	3,000	30.0	....	Do.
Huffs Ferry	do	575	Aug. 1, 1891	5.0, Loudon, rising	11,150	.....	.....	.....	2.282	25,350	....	....	.....	.....	....	....	Do.
Do	do	575	Oct. 23, 1891	0.9, Loudon, stationary.	8,050	.....	.....	.....	0.851	6,850	....	....	.....	.....	....	....	Do.
Do	do	575	Extreme low water.	—1.0, Loudon	5,500	.....	.....	.....	.....	*3,850	....	....	.....	.....	....	....	
1 mile above mouth	Clinch	556	Oct. 25, 1891	0.2, Kingston, stationary.	1,265	.....	.....	.....	0.632	800	....	....	.....	.....	....	....	Do.
Do	Hiawasse	489	Oct. 29, 1891	0.8 above low water, stationary.	2,100	.....	.....	.....	0.762	1,650	....	....	.....	.....	....	....	Do.
Shoddy Shoals	Tennessee	473	Dec. 12, 1892	2.3, Chattanooga, rising.	.....	.....	.....	.....	.....	13,700	....	....	.....	.....	....	....	Do.
Chattanooga	do	451	Nov. 13, 1891	3.0, Chattanooga, rising.	7,940	1066.1	7.747	.00015	2.211	17,560	66.0	.034	2.200	17,470	66.0	.034	Assistant Engineer D. L. Sublett.
Do	do	451	Extreme low water.	0.0 Chattanooga	4,710	1025.5	4.593	.00015	1.561	*7,365	59.4	.034	1.520	7,160	58.0	.034	
Do	do	451	Apr. 11, 1892	3.0, Chattanooga, falling.	39,720	1351.9	29.381	.00015	4.910	195,000	77.0	.034	5.310	210,900	80.0	.034	
Do	do	451	Jan. 15 and 16, 1892.	35.0, Chattanooga, rising.	49,750	1932.8	25.740	.00015	4.824	240,000	80.4	.034	4.860	242,000	81.0	.034	Do.
Do	do	451	Mar., 1875	54.0, Chattanooga	95,000	2592.9	36.638	.00015	.....	.....	....	....	6.300	598,500	85.0	.034	
Do	do	451	Mar., 1867	58.0, Chattanooga	104,715	2668.8	39.238	.00015	.....	.....	....	....	6.550	685,800	85.5	.034	
Tumbling Shoals	do	442	Nov. 5 and 6, 1891.	1.2, Chattanooga, stationary.	8,710	742.0	11.738	.00015	0.942	8,200	28.0	....	0.990	8,700	29.0	.100	Do.
Do	do	442	Extreme low water.	0.0, Chattanooga	7,840	711.9	11.012	.00010	0.931	*7,300	28.0	....	0.960	7,500	29.0	.100	Do.

*Estimated.

Discharge data, Tennessee River and tributaries—Continued.

Location of discharge section.			Date of observation.	Stage (gauge and condition).	Data and results derived from observation.								Results by formula.				Name of observer, etc.
Place.	River.	Distance above Paducah.			Area of section.	Wetted perimeter.	Hydraulic mean depth.	Slope.	Mean velocity per second.	Discharge per second.	Coefficient *C*, Chezy formula.	Coefficient *N*, Kuttesr formula.	Mean velocity per second.	Discharge per second.	Coefficient *C*.	Assumed coefficient *N*.	
		Miles.			*Sq. ft.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Cu. ft.*			*Feet.*	*Cu. ft.*			
Tumbling Shoals	Tennessee	442	Mar., 1875	54.0, Chattanooga...	71,000	1495.3	47.482	.00015	.....	.....	....	....	7.430	527,500	88.0	.034	
Do.....	.....do	442	Mar., 1867	58.0, Chattanooga...	77,000	1541.0	49.967	.00015	.....	.....	....	....	7.800	593,000	89.0	.034	
Florence.....	.....do	255	Mar. 30, 1888	20.0, Florence, stationary.	45,550	.....	.....	.....	5.500	250,000	....	....	.....	.....	....	....	Lieut. H. E. Waterman.
Do.....	.....do	254	Sept. 21, 1891	1.4, Florence.....	10,300	.....	6.900	.00005	.....	*22,444	....	....	1.230	12,700	66.5	.034	
Do.....	.....do	254	Extreme low water.	—0.8, Florence.....	7,000	.....	4.700	.00005	.....	.....	....	....	0.920	6,500	60.0	.034	
Colbert Shoals	.....do	230	Oct., 1889	3.0, Florence.....	13,400	.....	8.420	.00006	1.380	18,500	60.0	....	1.550	20,900	69.5	.034	Assistant Engineer B. B. Smith.
Do.....	.....do	230	Extreme low water.	—0.8, Florence.....	8,000	.....	4.660	.00006	.....	.....	....	....	1.000	8,000	59.0	.034	
Riverton.....	.....do	224	Oct., 8, 1894	—1.0, Riverton, stationary.	4,610	1080.2	4.267	.000147	2.222	10,250	88.8	....	1.610	7,400	64.0	.030	Assistant Engineer Geo. W. Brown.
Do.....	.....do ...	224	.....	—1.0, Riverton.....	4,610	1080.2	4.267	.000275	.....	.....	....	....	2.000	9,300	58.5	.034	
Do.....	.....do	224	Extreme low water.	—1.7, Riverton.....	3,960	.....	3.660	.000275	.....	.....	....	....	1.800	7,200	55.5	.034	
26 miles above mouth.	Duck	124	Sept. 8, 1879	1.0 above low water.	950	.....	.....	.....	1.170	950	....	....	.....	.....	....	....	Assistant Engineer D. L. Sublett.
Livingston Point	Tennessee	4	Oct. 19, 1894	0.4, Paducah, stationary.	8,635	1406.0	6.142	.000038	1.174	10,150	76.5	....	1.120	9,710	73.5	.030	Assistant Engineer Geo. W. Brown.

* Very doubtful.

Velocity relations.

[Surface velocities were taken at a depth of 1 foot and bottom velocities 6 feet above the bottom.]

Location.	Date.	Gauge reading.	Mean velocity per second.	Surface velocities.				Mid-depth velocities.		Bottom velocities.		Number of single observations.
				Mean of all observed surface velocities.	Mean velocity ÷ mean surface velocity.	Maximum observed surface velocity.	Mean velocity ÷ maximum surface velocity.	Mean of all observed mid-depth velocities.	Mean velocity ÷ mean mid-depth velocity.	Mean of all observed bottom velocity.	Mean velocity ÷ mean bottom velocity.	
			Feet.									
Knoxville	May 28, 1891	2.5	1.87	2.15	.87	2.52	.74	1.94	.96	1.42	1.32	300
Huffs Ferry	Aug. 1, 1891	5.0	2.28	2.75	.83	3.09	.74	2.57	.96	.....	.....	125
Chattanooga	Nov. 13, 1891	3.0	2.21	2.35	.94	2.83	.78	2.17	1.02	.....	.....	250
Do	Jan. 15 and 16, 1892	35.0	4.82	6.63	.72	7.35	.66	5.20	.93	.....	.....	50
Do	Apr. 11, 1892	30.0	4.91	6.00	.82	7.00	.70	5.40	.91	.....	.....	50
Riverton	Oct. 8, 1894	—1.0	2.22	2.27	.98	2.94	.77	2.17	1.00	1.74	1.28	150
Livingston Point	Oct. 19, 1894	0.4	1.17	1.10	1.06	1.72	.68	1.20	.97	.85	1.35	300

APPENDIX D.

REPORT OF MR. R. R. THACHER, SUPERINTENDENT.

HARRIMAN, TENN., *June 30, 1896.*

CAPTAIN: I have the honor to submit the following report on operations on the Tennessee River above Chattanooga for the fiscal year ending June 30, 1896:

The work at Hanging Rock Shoals, French Broad River, having been suspended, the fleet was taken in tow by steamer *Long* on July 26, 1895, and brought down to Kingston, Tenn., where such boats and property as were not needed on the French Broad had been left undergoing repairs. These boats and property were added to the tow brought from Hanging Rock Shoals and taken to Caney Creek Shoals, reaching there July 30, 1895.

Active operations were at once begun.

The whole force was put to work quarrying stone for dam. The incline from quarry to river was regraded and repaired.

On August 19 channel excavation was begun. In this work our drilling raft was used and it proved a great success, saving 60 per cent in drilling over the old way.

The channel here crosses the river from right bank to left bank just below the island. The old crossing, leaving the right bank 1,100 feet below Caney Creek, was very crooked and hard for boats to follow, especially at night or in windy weather. The new crossing is located 1,600 feet below the old and is straight, with a width of 200 feet in the clear, over which will be not less than 3 feet of water. It will be well marked out with buoys, and large wooden diamond-shaped targets will be placed on posts on the bank to enable pilots to follow it. The crossing is nine-tenths excavated and boats are using it now, owing to a sand bar that formed in the old crossing last winter. The stone excavated from the channel was placed on dams and some also used in riprapping the bank from mouth of Caney Creek to the new crossing.

On November 14 the temperature of the water reached 52°, and it was too cold for the men to work in it any longer. Channel work was then abandoned for the season. The force was put to building crib and lengthening out the lower dam.

A crib was built at head of shoals 300 feet long, of 6 by 12 inch best white oak 20 and 35 feet long, and the back tied with logs well drifted with ¾-inch driftbolts.

The bank at head of shoals was cutting and caving in, the deposit lodging in the channel just below and forming a troublesome bar. The crib was constructed to prevent the cutting and to allow check dams to be built out from the main dam opposite in order to remove the sand and gravel bar near there.

The crib was filled with stone boated from quarry.

The lower dam was lengthened out 872 feet to back up the water over the shallow part of the channel, and the additional length has added 1 foot of water to the channel. To this dam will be added check dams similar to those at White Creek Shoals.

Owing to the work here being scattered over a distance of 2½ miles and only partly finished, no great results can be expected at this stage of the improvement, although we expect to get a depth of 3 feet at low water when the improvement is completed.

Work was closed December 2. Boats and property were towed by steamer *Long* to Kingston, Tenn., and put into winter moorings.

During the winter the boats were overhauled and one new quarter boat and one hull were built. The cabin of an old boat was transferred to the new hull and lengthened out.

On April 29, 1896, fleet was towed from Kingston, Tenn., to Caney Creek Shoals, where work is now in progress quarrying rock for dams.

Since arriving at Caney Creek Shoals two new derrick boats have been built.

Two No. B. B. Providence power capstans have been added to the plant.

Two steel grabs have been made to go with steam derrick boats.

The fleet has received such repairs as general mending, calking, and painting.

I have the honor to also submit the following remarks on the improvements heretofore effected at White Creek Shoals and at Soddy Shoals:

White Creek Shoals.—At the end of the dam that extended from the foot of the island was a sand and gravel bar 400 feet long and 150 feet in width that divided the channel. One channel followed the bank, the other went between the bar and end of the dam. This shoal was considered by boatmen the "head of navigation" at a medium stage of water. Several steamboats were hung up all summer through trying to run down the channel that went out at the point of the dam. The bank channel could only be used in a good boating stage, for at the time of Lieutenant Waterman's survey (August, 1888) there was less than 1 foot of water in it, and it was very narrow. The improvement was made by extending the main dam to a total length of 1,035 feet downstream, and by adding to it two check dams, one 133 feet and the other 215 feet long.

The longitudinal dam was first extended 370 feet and the first check dam so built as to scour out the bar and to throw as much of the material as possible on the proposed line of the longitudinal dam in order to shallow up the water.

Along this line the water was from 6 to 10 feet deep. The above arrangement of dams filled it up about 3 or 4 feet, after which the longitudinal dam was further extended downstream and the other spur dam built.

The work has proved a success, for there in not less than 3 feet in the channel at low water where previous to the improvement there was less than 1 foot, and the boating season to Kingston has been extended several months.

These dams are so located as to be self-dredging. The bar forms each year, at high tide, as it did before the improvement, but as soon as the water recedes enough for the dams to take effect the bar is cut out in a few hours.

I have known of no boat having any trouble there since the improvement.

Soddy Shoals.—The work here was mostly excavation of solid reefs from the mouth of Soddy Creek to the lower end of the shoals. The longitudinal dam from the foot of the island was low in places and very leaky. The water level was the same on both sides of the dam. This dam was raised about 1 foot and well calked, which made a difference of water level near the island of 1 foot. The channel was also cleared of logs and loose rock and the reefs were blasted out.

The left wing of the lower dam was lengthened and one reef was padded to replace the water that had been taken from the channel by the removal of the reefs. A check dam was to have been built just below the padded reef to strengthen the current, but a sudden rise prevented its construction.

Before the last improvement less than 1.5 feet was found on the reefs (see Captain Biddle's report on survey of this shoals) where there is now not less than 3 feet at low water.

After White Creek Shoals were improved Soddy Shoals were considered by steamboat men the worst shoals between Caney Creek and Chattanooga. Several steamboats and many barges were sunk there.

All dangers to navigation have been removed, and I have heard no complaints since the last work was done.

The following table gives the items of cost of the principal kinds of work done at Caney Creek Shoals during the fiscal year:

Work.	Quantity.	Cost.				Unit cost.
		Labor.	Subsistence.	Materials.	Total.	
Quarrying stone, cubic yards.	7,938	$3,845.99	$410.22	$183.05	$4,445.26	$0.56 per cubic yard.
Earth stripping...cu. yds..	2,755	785.25	87.77	19.95	892.97	$0.32 per cubic yard.
Final costs quarrying, cubic yards.	7,938	4,631.24	497.99	209.00	5,338.23	$0.68 per cubic yard.

Work.	Quantity.	Cost.				Unit cost.
		Labor.	Subsistence.	Materials.	Total.	
Riprap dams:						
Quarrying....cu. yds..	2,061	.....	.....	.....	$1,442.70	
Building dams, cubic yards.	2,061	$897.80	$99.17	$25.00	1,021.67	
Final cost....{cu. yds.. / feet.....}	2,061 / 937	.....	.....	.....	2,464.37	$1.19 per cubic yard; $2.63 per foot.
Bank protection, riprap, cubic yards.	1,276	327.00	34.80	.....	361.80	$0.28 per cubic yard.
Channel excavation:						
Solid rock.....yards..	1,299	1,909.15	205.27	243.47	2,357.89	$1.81 per cubic yard.
Loose rock .....do....	63	43.10	3.28	6.50	52.88	$0.84 per cubic yard.
Crib .....feet..	300	511.98	67.39	198.36	777.73	
Stone filling .....cu. yds..	874	.....	.....	.....	611.80	
Final cost.....feet..	300	.....	.....	.....	1,389.53	$4.63 per foot.

Respectfully submitted.

R. R. THACHER, *Superintendent.*

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

APPENDIX E.

REPORT OF MR. W. A. M'FARLAND, ASSISTANT ENGINEER.

UNITED STATES MUSCLE SHOALS CANAL,
Lock 6, November 16, 1895.

LIEUTENANT: I have the honor to submit the following report on construction of spur dam at the lower entrance to the United States Muscle Shoals Canal, Alabama.

The object of the dam is to form a harbor below Lock 9 to facilitate the entrance of boats into the canal during the higher stages of the river. Heretofore the river current passing the point south of the lower lock abutment has formed a very troublesome eddy, the current running upstream along shore toward the lock entrance and then sweeping south past and very close to the south abutment.

On December 5, 1894, I submitted to Capt. John Biddle, Corps of Engineers, United States Army, a plan and estimate of cost for the construction of a riprap spur dam, beginning at the rocky point near the lower end of the lock and quartering out and downstream in a straight line, making an angle of 40° with the lock axis; dam to be built to level of ordinary high water. I subsequently recommended that the plan be modified to permit the construction of the dam to ordinary low-water level, and that the result of this work be observed before the dam is built to the originally proposed height.

The approved project for spur dam as submitted to the Chief of Engineers, United States Army, by Capt. Theo. A. Bingham, Corps of Engineers, United States Army, April 24, 1895, is as follows:

"It is proposed at first to build the dam only to the height of ordinary low water, as shown on the sketch and to observe the results. But the estimate herewith is based on a height to ordinary high water, which it is thought may prove necessary in the end. * * *

"The cost of riprap in place is estimated as 6,877 cubic yards, at $1.20 = $8,322, including 10 per cent for contingencies."

The work of quarrying stone for this dam was begun on May 16, 1895, at a point on the rocky bluffs about 200 yards downstream from the site of the work. Owing to the flinty and seamy character of the stone used, it was found impracticable to drill with churn drills, so all holes were put down by use of striking hammers.

Total number of cubic yards quarried, measured in place, 2,989.

After this amount of stone had been thrown down the work of carrying it to the site of the dam was begun. Plant employed was as follows: 2 stiff-leg horsepower derricks at stone pile; 1 stiff-leg and guy steam derrick at landing; 1 steam derrick boat at dam; double-track 48-inch gauge gravity railway (200 feet long) at quarry; 2 small flat cars; 2 deck barges 20 by 80 feet and 18 by 75 feet in deck plan.

First stone placed in dam September 4, 1895.

Number of cubic yards stone placed in dam (solid measurement), 2,864. Allowing 20 per cent for voids, as estimate was for stone in place, brings this amount up to 3,437 cubic yards.

Total length of dam built, 360 feet. Work suspended November 5, 1895.

Mean number of men employed, 25.

The dam was brought up to a height of 2 feet above mean low water, as it is thought that the swift current over the top of the dam at high water will displace many of the crest stones.

The following is a summary of amounts and costs, 20 per cent being added to reported amounts of stone quarried, to reduce same to cubic yards in place in dam:

Number cubic yards quarried, 3,582.	
Total cost of quarrying, $1,352.	
Cost of quarrying per cubic yard	$0.377
Number cubic yards placed in dam, 3,437.	
Total cost of placing, $1,417.	
Cost per cubic yard	0.4948
Due owner of land for stone, $137; per yard	.04
Subsistence	.09
Total cost per yard in dam	1.0018
Estimated cost	1.20

Respectfully submitted.

W. A. MCFARLAND,
Assistant Engineer.

Lieut. JAMES F. MCINDOE,
Corps of Engineers, U. S. A.

APPENDIX F.

REPORT OF MR. SYDNEY B. WILLIAMSON, ASSISTANT ENGINEER.

RIVERTON, ALA., *June 30, 1896.*

CAPTAIN: I have the honor to submit the following report of operations at Colbert Shoals during the fiscal year ending June 30, 1896, the work in progress being the construction of the 25-foot lift lock at Riverton, Ala., in accordance with the approved project of 1892 for improving Colbert and Bee Tree shoals.

In connection with the lock construction, a sandstone quarry is operated near Cherokee, Ala., 18 miles from Riverton.

All stone is transported over the Memphis and Charleston and the Northern Alabama railroads. All work is being done by hired labor.

GENERAL DESCRIPTION OF LIFT ROCK.

Detail dimensions of the lock are given on plate No. 1 of the accompanying drawings; the principal dimensions may be summarized as follows:

	Feet.
Total length of lock	551½
Clear width	80
Height of lock walls	37
Width of bottom course, lock walls	21½
Width of coping course, lock walls	5
Width of coping course, gate abutments	30
Length between hollow quoins	350
Length between lower and guard gates	40
Height of lift walls	25¾
Width of bottom course, lift wall	10
Width of coping course, lift wall	6
Width of bottom course, gate abutments	34

There are fifteen courses, varying from 3 feet 6 inches to 1 foot 9 inches; the first and second courses from the foundation are of limestone, as are also the fourteenth and fifteenth, the latter being the coping. The remaining courses are sandstone. The lift wall is built of limestone; the minimum and maximum courses are respectively 3 feet and 3 feet 6 inches (coping 2 feet 9 inches). The miter sills and wall are circular arcs, their upstream faces having 65 feet 1 inch radii.

There are to be three pairs of gates, the upper and lower gates proper and the lower guard gates. The form and dimensions of the culverts may readily be seen from the drawings.

PLANT AT LIFT ROCK.

Excepting the small portion mentioned in the report for 1895, the entire plant has been installed during the present year. A description is facilitated by the following classification:

Water supply.—Water is obtained from a spring located 2,300 feet south of the lock site, and is conducted through a 2-inch pipe by gravity to a 7,000-gallon tank in the material yard. The latter supplies eight boilers, aggregating 206 horsepower, and in addition all of the water used for mixing concrete and mortar, washing stone, and drinking purposes. The discharge at the spring is 11.99 gallons per minute and into the tank 9.67 gallons per minute, the head being 9.1 feet.

Pumping plant.—As originally erected, the pumping plant consisted of a 9-inch centrifugal pump, with 2,600 gallons per minute capacity, driven by a 35-horsepower stationary engine; a similar pump was purchased as a duplicate. These were interchanged for necessary repairs, and successfully drained the pit, with a lift of 37½ feet, until February, 1896.

At that time, owing to a slight break in the levee, the centrifugal pump was covered with quicksand and rendered temporarily useless. To avoid a recurrence of the above experience, a steam pump of the following dimensions was purchased: Steam cylinder, 14 inches; water cylinder, 8 inches; stroke, 20 inches; suction, 6 inches; and discharge, 4 inches. Having repaired the centrifugal pump, either one or the other was used for pumping. The total lift of the steam pump is 42¼ feet, the suction being 12½ feet. Under ordinary conditions it is not necessary to pump over four hours in twenty-four. During a second flood, in April of the present year, the centrifugal pump failed again, and, as the steam pump alone was not equal to the emergency, the pit was partly filled with water. The centrifugal pump has been abandoned because of its inaccessibility for repairs. The existing plant consists of the above-mentioned steam pump, which is ample for ordinary service, and a recently purchased duplex pump, which may be used in emergencies. The dimensions of the latter are as follows: Steam cylinder, 14 inches; water cylinder, 12 inches; stroke, 12 inches; suction, 10 inches; and discharge, 8 inches; maximum capacity, 1,170 gallons per minute.

Shops and storerooms.—These were completed during the last fiscal year. During the present year a tooth-chisel machine was added to the shop appliances, an oil house erected, and some minor improvements made in the tool-room.

Traveling cable way.—The lock pit is spanned by a Lidgerwood traveling cable way, which is used for conveying all excavated material from the pit, filling behind the walls, moving engines, erecting derricks for construction, and removing the damaged piling that surrounded the pit. The cable way has an "aerial dump" attachment and is especially efficient in filling behind the lock walls. The span is 370 feet; maximum safe load, 5 tons; and the capacity, approximately 400 cubic yards per day of eight hours. The head and tail towers are respectively 60 and 35 feet high and are erected on counterbalanced cars. Each car may be moved on three parallel tracks extending the length of the pit. An elevation of the cable way is shown on plate No. 2.*

Construction derricks.—Masonry is laid with four stiff-leg derricks, capable of hoisting 10 tons each. Their booms are 12-inch square timbers 60 feet long, and are trussed with four iron rods. Each derrick is maneuvered by a 7 by 10 inch double-cylinder, double-drum hoisting engine.

Cable road.—The material for construction is conveyed into the lock pit by an endless cable road which passes from the yards into the pit upon an incline. The cable is a ¾-inch, 7-wire, cast steel rope, 2,000 feet long, operated by a reversible link-motion haulage engine, with 10 by 12 inch cylinders. Steam is supplied by a 60 horsepower return tubular boiler, which also furnishes the pumping and shop engines.

Stone-yard derricks.—Four guy derricks are used for unloading, cabling, and reloading the rubblestone. Two of these are maneuvered by hoisting engines, the remainder by horsepowers.

Traveling crane.—The duties of the traveling crane are to handle all of the cut stone from the time it is received rough from the quarry until it is loaded for transferring to the lock walls. All parts of the crane are of wrought iron. It consists essentially of a 14-foot mast and 30-foot boom placed on a counterbalanced car. The operating engine is a double-cylinder duplex hoisting engine with 6¼ by 10 inch cylinders, which controls all of the movements. The maximum load is 10 tons; hoisting speed, 13 feet per minute; traveling speed, 150 feet per minute.

There was no field riveting in erecting, the parts being bolted together, so that the machine may readily be taken apart. The track is laid with 56-pound steel rails on stringers; its length is 540 feet, and gauge 12 feet. The weight of the machine distributed over its long wheel base tends to curve the rails up at the joints. In future the track should be laid with heavier rails or a specially devised joint fastening.

Cost of plant.—The first cost, cost of improvements, and maintenance are tabulated on page 2026.

* Not printed.

Total cost of plant at Riverton to June 30, 1896.

Designation.	Began operation.	First cost.	Additions and improvements cost.	Maintenance cost.	Percentage of first cost.			Remarks.
					Additions and improvement.	Maintenance.	Total.	
	1895.							
Pumping and water supply.	June..	$1,360.72	$1,141.97	$343.20	$0.83	$0.25	$1.08	Additions include duplicate pump.
Shops and storerooms..	June..	318.10	44.02	28.83	.13	.09	.22	
Traveling cable way...	Aug ..	7,103.62	193.60	975.76	.03	.13	.16	Maintenance includes duplicate drum, shaft, and one set of extra sheaves.
Construction derricks..	Aug ..	4,046.80	446.62	215.25	.11	.05	.16	
Cable road.....	Sept ..	3,215.90	591.96	480.37	.18	.14	.32	
Stone-yard derricks....	July ..	2,176.05	621.90	177.27	.28	.08	.36	
Traveling crane.....	Sept ..	7,181.90	85.14	249.13	.01	.03	.04	Maintenance includes one set of duplicate sheaves on hand.
Miscellaneous tools, etc.	July ..	1,455.49	346.20	432.85	.23	.29	.52	
Total	.....	26,858.58	3,471.41	2,902.66	.12	.11	.23	

EXCAVATION.

The condition of the lock pit at the beginning of the present fiscal year was practically as is shown by the photograph taken May 17, 1895.

During July and August following a portion of the contractors damaged pile revetment was removed from the south side, and the bank partly sloped. The embankment of gravel which the contractor had placed along the center line of the pit, was moved to the north side, in order to lay the cable road tracks. Only a small portion of the material excavated, during these two months, was removed from the pit, as it was considered more economical to simply transfer it so as to make space for erecting the plant; and rehandle with the cable way; rather than attempt elevating said material through a vertical distance of 30 feet, at that time, wheelbarrows being the only appliances available. The status of the excavation when the cable way began operating, is shown by the photograph * of August 31, 1895.

Subsequently the cable way has been used for conveying all excavated material, removing damaged piles, and filling behind the lock walls. Upon the failure of the timber revetment the sustained earth broke along the line of anchor piles, 40 feet back from the face, and a wedge-shaped mass sloughed off into the partly excavated pit. By reason of the increased yardage from the above cause, and the limited space for waste material, it has been necessary to rehandle a large portion of the excavation. For example: The material removed from the site of the south wall was first conveyed to the north side of the pit, subsequently reloaded and used for "back filling" behind the south wall. The material is picked, when necessary, and shoveled into wooden skips of 2½ cubic yards capacity. The latter are elevated above the surface, conveyed to the desired point and automatically dumped by the cable way. The solid rock, having been blasted, is loaded into the skips by hand. The various classes of material encountered are as follows:

[Average distance of water level above surface of rock, 20.3 feet.]

Classification.	Average depth.	Weight per cubic foot.
	Feet.	*Pounds.*
Surface soil	7.3	99.8
Sandy loam	11.3	112
Quicksand	9	118
Gravel	4	138
Solid rock	6.5	.....
Total	38.1	.....

* Not printed.

The manifest failure of the timber revetment used by the contractor showed the necessity of adopting other methods for sustaining the sides of the pit. Having ascertained that the so-called quicksand would stand at a slope of 1 on 1, if kept drained, the sides were excavated at said slope throughout. To prevent sloughing, during wet weather, a portion of the excavated rock has been used for building a dry retaining wall, 9 feet high and about 4 feet wide, along the foot of the slope. The adopted plan has been very effective, except in one instance, under most trying conditions as follows: During the flood of April, 1896, the pit was partly flooded, so that the retained quicksand was thoroughly saturated. Approximately 1,000 cubic yards slid into the pit carrying about 50 linear feet from an unfinished end of the dry wall with it. The classification, amount, and cost per cubic yard of material moved during the year are given below.

Material excavated during the fiscal year 1896.

Month.	Excavation.				Embankment.				Remarks.
	Solid rock.		Earth and gravel.		Back filling.		Level and tracks.		
	Cubic yards.	Cost per cubic yard.	Cubic yards.	Cost per cubic yard.	Cubic yards.	Cost per cubic yard.	Cubic yards.	Cost per cubic yard.	
1895.									
July	.....	.....	3,620	$0.20	.....	.....	.....	.....	Moved with wheelbarrows.
August	706	$0.94	4,200	.17½	.....	.....	.....	.....	Do.
September	1,847	.72	3,102	.15	.....	.....	.....	.....	Moved with cable way.
October	2,023	.54	5,674	.19¼	.....	.....	.....	.....	Do.
November	1,211	.80	3,809	.21¼	1,123	$0.13	.....	.....	Do.
December	300	.70	1,676	.19½	852	.13	470	$0.14	470 cubic yards moved with wheelbarrows.
1896.									
January	.....	.....	1,500	.13	6,635	.10	.....	.....	Moved with cable way.
February	389	.71	1,325	.14	1,740	.11½	543	.17	543 cubic yards moved with scrapers; balance with cable way.
March	379	1.17	831	.09½	6,225	.06	.....	.....	Moved with cable way.
April	130	.70	4,100	.20	1,120	.07	.....	.....	Moved with cable way and derricks; increased cost due to earth slide.
May	645	.86	7,060	.19	3,000	.06½	.....	.....	A portion handled twice.
June	412	.96	6,690	.11	2,600	.09½	.....	.....	
Total	8,042	.75	51,097	.16	23,295	.94	1,013	.....	

The above unit costs include building the dry wall, removing piles, and other miscellaneous work, the cost of which is difficult to separate. Under favorable conditions 400 cubic yards of earth and gravel have frequently been removed in eight hours, at a total cost of $36, or 9 cents per cubic yard, including dumping behind the wall.

STONECUTTING.

The number of cubic yards of stone purchased from the contractor by estimates, and from the receiver subsequent to the annulment of the contract are as follows:

Class.	Limestone.		Total.
	Purchased from contractor (estimates).	Purchased from receiver.	
	Cu. yds.	*Cu. yds.*	*Cu. yds.*
Fine pointed	658	545.47	1,203.47
Rough pointed	174	.....	174
Rock face	18	.....	18
Rubble	3,215	572.74	3,787.74
Rough stone	.....	145.22	145.22
Total	4,065	1,263.43	5,328.43

There has also been purchased 108 cubic yards of granite quoins from the Southern Granite Company, and 265 cubic yards of limestone coping from the T. L. Fossick Company. The latter is delivered sawed one way and is dressed at the lock. The remainder of the stone is sandstone from the Cherokee quarry and has been cut by hired labor in the Riverton stone yard.

Classification of fine pointed.—The face of fine-pointed stone is bounded by a chisel draft 1 inch wide; the remaining portion is dressed to a true surface conforming to the draft lines, with no depressions greater than one-eighth of an inch. The face is finished with a tooth ax instead of a pointing tool.

Rough pointed.—The plane of the face of rough-pointed work is fixed by a pitch line, there are no depressions and the projections do not exceed 1 inch.

Rock face.—The face of this class is left rough; it is surrounded by a pitch line that determines a plane below which there are no depressions, and no projections over 4 inches.

Beds and joints.—The beds of the above classes are dressed throughout so as to be laid with one fourth inch bed joints. The vertical joints are similarly dressed for 12-inch back from the face, the remainder being roughly cut to form 1-inch joints.

Detail stones.—Under this head are the miter sills, coping, arch stones. and quoins. Their exposed surfaces are fine pointed, and the beds and joints are cut throughout for laying with one-fourth inch joints. Excepting the coping of the straight wall between abutments, each stone has been cut from detail drawings and patterns. The granite quoins are delivered cut, in accordance with patterns furnished by the United States. The surface of the hollow is finished with a patented eight-cut hammer.

Rubble.—The rubble backing is simply scabbled. The beds are scabbled for 1-inch joints; as a general rule the vertical faces are dressed for similar joints, though occasionally odd shapes necessitate larger ones. The number of cubic yards cut during the past year are given in the following table:

Stone cut during the fiscal year 1896.

Month.	Fine pointed.	Rough pointed.	Rock face.	Miter sills.	Coping.	Arch.	Rubble.	Grooves.
1895.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Sq. feet.*
July	.....	.....	.....	.....	.....	10	5½	.....
August	222	2	.....	.....	.....	22	708	75
September	258	45	.....	7½	.....	34	619½	65
October	330	118	.....	.....	.....	40½	252	50
November	292	55	.....	.....	.....	25	188	188
December	178	29	.....	.....	16	.....	229	115
1896.								
January	156	.....	.....	41	15	79	827	58
February	162	.....	.....	.....	46	25	637	92
March	191	26	12	19	8	25	700	72
April	148	22	.....	6	27	.....	496	141
May	166	10	.....	7	85	1	665	100
June	156	12	.....	.....	33	42	351	42
Total	2,259	319	12	80½	230	303½	5,678	998

Cost.—The following information as to unit costs of cutting stone is given with the hope that it may be useful in future estimates of similar work. The records have been carefully kept with this in view.

The figures of Table A represent the work performed by the stonecutters alone.

TABLE A.—*Actual unit cost for stonecutters wages alone.*

Classification.	Number of cutters.	Cubic yards cut.			Average cost per cubic yard.	Total number of days (eight hours) labor.	Average price paid per hour.	Cubic yards cut per day of eight hours.	Total number of square feet of face.	Average cost per square foot of face.
		Face stone.	Backing attached.	Total.						
Sandstone:							*Cents.*			*Cents.*
Fine pointed...	299	1,821.72	912.46	2,734.18	$3.77	3,277½	392	0.834	19,674.58	52
Rough pointed*	136	274.68	128.56	403.24	3.39	430¾	397	.934	2,966.58	46
Rock face*	8	12	4.92	16.92	3.51	18½	40	.911	129.08	46
Arch	125	221.11	29.78	250.89	7.48	588¼	40	.426	2,989.49	63
Rubble†	.....	.....	.....	3,376.23	.86	.....	15	.....	.....	.....
Grooves	74	.....	.....	.....	.....	.....	40	.....	.....	.....

* Special stones, curved faces.

† Scabbled.

The following figures for cutting limestone are of little value, except those for coping and grooves, as the remaining classes were simply remodeled from stone previously cut by the contractor. The unit costs are, therefore, too small for stone cut from the rough.

Classification.	Number of cutters.	Cubic yards cut.			Average cost per cubic yard.	Total number of days (eight hours) labor.	Average price paid per hour.	Cubic yards cut per day of eight hours.	Total number of square feet of face.	Average cost per square foot of face.
		Face stone.	Backing attached.	Total.						
Limestone:							*Cents.*			*Cents.*
Fine pointed*	43	181.58	55.29	236.87	$3.90	288½	40	0.821	1,961.08	47
Rough pointed*	12	17.54	5.32	22.86	3.42	24½	40	.932	189.41	41
Coping	53	144.62	.....	144.62	5.30	231	40	.643	803.41	95
Miter sills*	40	115.57	.....	115.57	2.35	84¾	40	.733	958.66	28
Grooves	15	.....	.....	.....	.....	.....	40	.....	160.76	75

*Remodeled.

No attempt has been made to separate the costs of the face stone from the attached backing in the above table; first, because to do so seems illogical, as a certain amount of backing is necessarily attached to all face stones; second, an element of uncertainty is introduced, as the cost of either the face or backing (preferably the latter) must be assumed. Should it seem proper to separate the two classes the figures above may be converted as follows: Consider the face stone 2½ feet wide, assume cost of backing attached to be $1 per cubic yard, and taking "fine-pointed" sandstone as an example, we have 2,734.18 cubic yards × $3.77 = $10,307.85, total cost; therefore, $10,307.85 — $912.46 = $9,395.39, the cost of face stones; $\frac{9395.39}{1821.72}$ = $5.15 the cost per cubic yard for face stone extending 2½ feet back.

The total unit costs of cutting are given in the following table. They are derived by adding the wages of the fireman, engineers, blacksmiths, and laborers and the material expended to the unit costs given in Table A.

TABLE B.—*Total unit cost of cutting stone.*

Classification.	Cost per cubic yard of cutting stone.			Cost per cubic foot.	Remarks.
	Stonecutter's labor.	Other labor and material.	Total.		
Sandstone:				*Cents.*	
Fine pointed	$3.77	$2.13	$5.90	22	
Rough pointed	3.39	1.91	5.30	19	Special stones with curved faces.
Rock face	3.51	1.99	5.50	20	Do.
Arch	7.48	4.22	11.70	43	
Rubble (backing)	.86	.10	.96	3½	Scabbled.
Grooves	.69	.18	.87	.....	
Limestone:					
Fine pointed	3.90	2.20	6.10	23	Remodeled (see Table A).
Rough pointed	3.42	1.93	5.35	20	Do.
Coping	5.30	3.00	8.30	31	
Miter sills	2.35	1.35	3.70	14	Do.
Grooves	.75	.35	1.10	.....	

The average cubical contents of 1,014 of the stones cut is 1.42 cubic yards. Wages of cutters, $3.20; engineers, $2; blacksmiths, $2.50, and laborers, $1.20 per day of eight hours. If the backing is separated the total cost of fine pointed would be $7.28 per cubic yard. (See note, Table A.)

For the past four months the time of a stonecutter engaged in dressing fine-pointed sandstones has been itemized in order to obtain the cost, per superficial foot, of cutting the face beds and joints. The results are given in Table C.

TABLE C.—*Itemized cost of cutting fine-pointed (tooth-axed) sandstone.*

[Number of stones cut, 23. Dimensions of average stone: Rise, 2 feet 6 inches; length, 3 feet 10 inches; width, 4 feet = 38.33 cubic feet.]

Dimensions of stones.	Per cubic foot.	Per cubic yard.
Rise, 2′ 6″; length, 3′ 10″; width, 4′ = 38.33 cubic feet	$0.15	$4.05
Rise, 2′; length, 4′; width, 3′ = 24 cubic feet	.18½	4.99
Rise, 2′; length, 4′; width, 5′ = 40 cubic feet	.15⅓	4.13
Rise, 3′; length, 4′; width, 3′ = 36 cubic feet	.15¾	4.25
Rise, 3′; length, 4′; width, 5′ = 60 cubic feet	.12⅝	3.42

	Rough, removed.	Number of square feet cut.	Cost per square foot.
	Inches.		*Cents.*
Face	2	273	24
Beds	1¾	856	8
Joints	1¾	438	5

An inspection of the above table shows that the cost of cutting varies inversely as the rise or width, other dimensions being equal. It follows, therefore, that economy in cutting is obtained by selecting heavy courses and as great width of beds as may be quarried.

FOUNDATION.

The reference of the foundation is 0.5 foot above datum and an average of 6.5 feet below surface of the solid rock. For a distance of 8 feet back from the face line of the wall the rock has been excavated to the full depth; in rear of this the shelly and disintegrated portion has been removed, so that a solid foundation is secured throughout. The rock (a blue limestone) for 2 feet below its surface is full of seams and generally unfit as a foundation. The remaining depth, as shown by frequent test holes drilled to 12 feet below subgrade, is hard and solid.

In the foundation of the upper gate recess of the south wall a test hole developed three horizontal seams, respectively 4, 6, and 10 feet below grade. The last was 5 inches wide and contained a stream of clear water from which the discharge at the surface was approximately 15 gallons per minute.

In order to examine minutely the foundation at this point a pit 8 feet square was excavated to the depth of the lowest seam. The upper seams disappeared within the excavated area and the walls presented a solid appearance for 10 feet in depth. The water from the remaining seam was confined within a small reservoir, from which it is allowed to escape through a 2-inch pipe leading to the surface in front of the filling culverts. The pit was refilled with rubble masonry and concrete. The rock is in layers from 6 inches to 2 feet thick and dips to the southwest at about 10° to the horizontal. In preparing the foundation it is found more expedient to excavate slightly below grade and refill with concrete than to "bull point" to the required grade. The surface of the rock is carefully cleaned and a thin layer of mortar is spread over it before the concrete is deposited.

MASONRY.

The classification of masonry is similar to that described for stonecutting. The parts of the wall built of the various classes are as follows:

Fine pointed includes the exposed face of the walls throughout, except the gate recesses; also the sides of the culverts, tops of the square culverts, and valve chambers.

Rough pointed includes the lower-gate recesses and as much of the upper recesses as are above the top of the well walls.

Rock face embraces the portion of the upper-gate recesses that is below the top of the well walls and the portion of the wing wall that is below low-water plane.

Sills include the miter sills and lift wall.

Quoins.—Under this head are the stones forming the curved surface of the hollow quoins and the pintle blocks.

Coping.—This class includes the coping proper and the top course of the well walls.

Cut stone includes all of the culvert arch stones.

Rubble.—The upper wing walls from the foundation to the upper level of the canal, the well walls in front of the filling culverts, and all parts of the lock not specified above are of rubble masonry.

Concrete.—Concrete is used for leveling the foundation, filling large irregular joints in the backing, and filling behind the walls to the surface of the solid rock. The spandrels of the arched culverts are filled with a layer of concrete 9 inches thick.

All concrete is made with Portland cement; for the foundation the proportions are one of cement, two of sand, and four of broken stone. It is mixed comparatively dry, well rammed in place, and flooded after the initial set. For filling joints and spandrels the proportions are one, three, and five, and for filling behind the walls a mixture of one, three, and seven is used.

Cement and sand.—Alsen's Portland cement (white label) is used throughout. For one-third of the height from the foundation the mortar is mixed one of cement to two of sand; for the remainder of the wall one to three is used. Sand is obtained from the Mississippi River at Memphis, Tenn.

Methods.—The face stones are laid with one-fourth inch beds and joints and backing with 1 inch. The mortar beds are made full and comparatively soft, so as to insure a firm bed, each stone being rammed in place. The vertical joints are filled with dry tamping mortar, which is thoroughly compacted with iron tampers. Large irregular joints in the backing are filled with concrete. The practice is to lay each course with stones of equal height from face to back of wall; occasionally this is varied from two courses of backing being substituted for one. The latter method is resorted to only when a scarcity of the required height of stone necessitates, as it is more expensive.

Quantities.—Masonry work was begun on September 30, 1895. Until April 4, 1896, the masons were engaged on the south wall; subsequently the construction of both walls has been in progress. All masonry work was temporarily abandoned from April 7 to 20, on account of high water and an earth slide which entirely covered the small portion of the north wall that had been built. The number of cubic yards laid during the fiscal year are tabulated below, and the portions of the walls constructed are shown on the accompanying progress profile, Plate No. 3:*

Masonry laid during the fiscal year 1896.

Month.	Concrete.	Rubble.	Fine pointed.	Rough pointed.	Rock face.	Sills.	Quoins.	Coping.	Cut stone.
1895.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
September*	2	.....	.....	.....	.....	4	2	.....	.....
October	107	580	178	20	.....	.....	10	.....	41
November	41	1,152	161	50	.....	.....	5	.....	41
December	15	691	159	50	.....	.....	5	16	1
1896.									
January	67	1,300	433	.....	.....	2	.....	15	29
February	55	1,500	210	.....	.....	48	.....	30	73
March	50	1,115	137	20	16	57	.....	10	27
April†	12	552	90	34	.....	.....	12	15	.....
May‡	50	1,197	203	19	.....	48	.....	79	.....
June§	254	1,975	334	137	.....	.....	.....	46	62
Total‖	653	10,062	1,905	330	16	159	34	211	274

*Began laying September 30. †Lost thirteen days from high water. ‡1,020 square feet pointing.
§3,103 square feet pointing. ‖4,123 square feet pointing.

Since January 1 the cost of laying masonry has been itemized so as to obtain the average cost per cubic yard and the relative cost of the different courses. The averages of the results are given in Table D.

TABLE D.—*Average unit cost of laying masonry.*

Rise.	Masonry laid.			Cost per cubic yard.			Remarks.
	Proportion of—		Total number of cubic yards.	Labor.	Mortar.	Total.	
	Face.	Rubble.					
Ft. In.							
3 6	1	3	1,494	$0.78	$1.09	$1.87	Proportions of mortar, 1 to 2.
3 0	1	3	2,290	.78	1.07	1.85	Do.
2 6	1	3	1,075	.79½	.90½	1.70	Proportions of mortar, 1 to 3.
2 3	1	3	370	.82	.78	1.60	Do.
2 0	1	3	890	1.07	1.00	2.07	Do.
1 9	1	3	768	1.04	.95	1.99	Do.
Coping.	1	.....	64	1.49	.71	2.20	Do.

Daily average for one derrick.—Force: 1 mason, at $3.60; 3 masons, at $3.20; 1 engineer, at $2; 3 laborers, at $1.20; 4 laborers, at $1. Masonry laid, 28½ cubic yards.

* Not printed.

Under similar circumstances the cost of laying varies in inverse ratio with the height of the courses. This fact is shown in the above table, though the difference is not so marked, because the 3 foot 6 inch and 3 foot courses contain the culverts and are laid with richer mortar. The cheapness of the 2 foot 3 inch course may be partly accounted for by the small proportion of face stone; otherwise there seems to be an error.

CHEROKEE QUARRY.

The so-called "Cherokee Quarry" is a formation of light-colored sandstone, located on top of a range of hills, 2½ miles east of Cherokee, Ala. The elevation above the plane of the adjacent country is approximately 300 feet.

The average height and width of the sandstone deposit are respectively 46 and 65 feet, and it extends half of a mile along the ridge. The stratification of the quarry is as follows:

1. Twenty-one feet of sand and inferior sandstone; one-fourth suitable for rubble.
2. Five feet of shelly stone, from 3 to 12 inches thick; stripping wasted.
3. Six feet of stone suitable for rubble backing.
4. Five feet of stone suitable for face or dimension work.
5. One foot of shelly stone, from 2 to 4 inches thick; stripping wasted.
6. Three feet of dimension stone.
7. One-half foot of shelly stone.
8. Five and one-half feet of dimension stone.

Total, 47 feet.

A larger amount of waste has been necessary than was indicated from the preliminary examinations, as some of the ledges presenting a solid face were found to contain irregular seams in the interior; the reverse was also found in some cases. There are vertical seams extending from top to bottom, which divide the ledges into rectangular prisms with superficial areas, varying between 800 and 2,000 square feet. The sandstone rests upon a strata of earth 15 feet thick, which overlies a dark-gray limestone.

Plant.—The erection of the quarry plant was completed during July, 1895.

Derricks.—Three guy derricks, maneuvered by horsepower are used for quarrying and loading on tramcars for transportation to the cable way.

Spur track.—The inaccessibility of the quarry necessitated the construction of a spur from the Memphis and Charleston Railway.

The track is a mile long, including a siding at the upper terminus, and has a uniform grade of 3 feet in 100; the maximum curve is 8°. The topography would not allow a nearer approach of the track to the quarry than 700 feet horizontally and 140 feet vertically without constructing an additional mile of track, with a "switchback" over very rough ground. The stone is conveyed from the quarry to the spur track by a suspension cable way.

Cable way.—The cable way is 700 feet long, with a capacity of 8 tons. The head tower is 60 feet high, and is at an elevation of 158 feet above the tail tower; the latter is 80 feet high. It is operated by a 50-horsepower engine, having 10 by 12 inch double cylinders and 54-inch drum. Each stone is taken from the quarry tramcars and loaded directly upon the railroad cars by the cable way. The number of cubic yards loaded during a day is limited by the amount that may be received at Riverton. Usually 80 cubic yards are loaded in eight hours, the cost of operating the cable way being $11, or 13¾ cents per cubic yard loaded. Under more favorable conditions for receiving stone, an average of 150 cubic yards per day could be easily loaded, which would reduce the unit cost to 7⅓ cents. The average stone contains 1½ cubic yards.

Water supply.—The water used for the cable way boiler, quarrying, and drinking is obtained from a spring 4,000 feet from the quarry, and is conducted through a 1-inch pipe.

Miscellaneous.—The miscellaneous work performed during the year is as follows: Erecting blacksmith shop, powder magazine, tool house, office, and shed for the cable-way machinery, hauling machinery and material, cutting and hauling derrick timbers, maintenance of tracks and machinery, repairing and sharpening quarry tools, and making railroad cross ties.

Methods.—For the first two months the quarrying was done by means of plugs and wedges; subsequently the Knox system has been used exclusively, and a great saving in the cost of quarrying and wasted material has resulted. A portion of the stripping or wasted material is used for ballasting the railroad tracks, and for embankments upon which the tram tracks are extended.

Quantities.—The amount of work performed is shown below:

Quantities of work done at Cherokee Quarry for the fiscal year.

Month.	Excavation.	Track laying.	Making cross-ties.	Stripping.	Stone quarried.	Stone scabbled.	Stone loaded.
1895.	*Cu. yds.*	*Lin. ft.*	*Number.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
July	1,027	6,000	900	5,280	625	425	.....
August	246	.....	.....	3,893	1,364	176	1,517
September	.....	.....	.....	12,780	1,448	.....	1,066
October	.....	.....	.....	5,898	1,027	.....	1,189
November	.....	.....	.....	3,328	1,434	.....	1,217
December	.....	.....	.....	2,131	1,167	.....	685
1896.							
January	.....	.....	.....	1,068	521	.....	189
February	.....	.....	.....	1,605	288	80	696
March	.....	.....	.....	1,848	375	378	1,195
April	.....	.....	.....	2,637	658	374	823
May	.....	.....	.....	724	1,072	471	1,641
June	.....	.....	.....	2,000	1,304	790	1,230
Total	1,273	6,000	900	43,192	11,273	2,694	11,448

REMARKS.—The excavation was for railroad tracks and to increase the clearance under the cableway. The stripping has been kept well in advance of the quarrying. There is, approximately, 7,000 cubic yards to be quarried, and but little stripping to be done.

Average unit costs.

Stripping, per cubic yard	$0.29
Quarrying, per cubic yard (including royalty on Knox system)	1.03
Scabbling, per cubic yard	1.08
Loading, for shipment, per cubic yard	.18

OFFICE WORK.

Cement tests.—In order to select the cement for construction, tests extending over thirty days were made of six brands of Portland and five of natural cements. The methods of testing recommended by the American Society of Civil Engineers were used, and the results were as follows:

TABLE E.—*Seven and twenty-eight day tests of various brands of cement.*

Brand.	Mark.	Time required for setting.		Per cent passing sieve.		Tensile strength (pounds per square inch).							
		Initial.	Hard.	No. 50.	No. 100.	Neat.		One part sand.		Two parts sand.		Three parts sand.	
						7 days.	28 days.	7 days.	28 days.	7 days.	28 days.	7 days.	28 days.
		Hrs. M.	*Hrs. M.*										
Portland	A.	2 20	5 10	98	81	630	759	275	313	221	245	135	167
Do	B.	2 02	6 07	99	88	416	519	230	275	171	231	117	153
Do	C.	0 30	6 00	99	85	383	543	243	340	127	189	77	99
Do*	D.	0 10	0 35	98	90	364	523	252	343	231	277	118	182
Do*	E.	0 12	0 20	99	91	296	383	196	258	126	199	97	146
Do*	F.	0 10	0 20	99	89	295	367	220	306	204	278	122	173
Natural*	L.	0 18	0 33	99	91	190	293	114	179	68	148	44	109
Do*	M.	0 6	0 12	77	50	145	175	73	148	43	77	21	52
Do*	N.	0 8	0 16	88	78	128	152	69	134	32	84	19	53
Do	O.	0 30	2 17	88	75	79	198	62	160	39	125	29	72
Do	P.	0 30	1 10	93	80	88	187	72	158	58	144	38	91

*Rejected for quick setting.

As a slow-setting cement was required, all of the above whose initial set occurred in less than 30 minutes were rejected regardless of their other properties. The cost per cubic yard of mortar made with the remaining brands is as follows:

TABLE F.—*Cost per cubic yard of mortar.*

Brand.	Mark.	Cost of one cubic yard of mortar.					
		Neat.	One part sand.	Two parts sand.	Three parts sand.	Four parts sand.	Five parts sand.
Portland	A	$20.44	$11.97	$8.70	$6.53	$5.46	$4.64
Do	B	22.63	13.18	9.54	7.13	5.94	5.03
Do	C	19.71	11.56	8.42	6.33	5.30	4.51
Natural	O	8.34	5.74	4.40	3.53	3.07	2.66
Do	P	8.34	5.74	4.40	3.53	3.07	2.66

Cost of sand, $1.10 per cubic yard.

The proportions of cement and sand shown below were used for computing the values of the above table:

Parts of sand to one of cement.	Amount required to make one cubic yard of mortar.			
	Portland.		Natural.	
	Cement.	Sand.	Cement.	Sand.
	Bbls.	*Cu. yds.*	*Bbls.*	*Cu. yds.*
0	7.3	.....	8.34	.....
1	4.05	0.57	5.19	0.50
2	2.8	.78	3.62	.71
3	2	.85	2.67	.78
4	1.6	.89	2.15	.84
5	1.3	.91	1.73	.85

Combinations of the results are shown graphically on Pls. 4 * and 5.* The curves representing the different cements are produced by platting the corresponding cost and strength as coordinates. The Portland cement marked A was chosen as being the most economical, because, as may be seen on Pl. 4, by varying the proportion of sand any desired strength (to 630 pounds per square inch) may be obtained in seven days, at less cost than a mortar of equal strength made from any of the remaining cements. The above is practically true for the twenty-eight-day tests shown on Pl. 5, though brand C excels in one instance. The latter falls short, however, in the higher values that are desired. Extensive tests have not been made during the progress of the work.

A sufficient number of barrels from each carload received are tested for time of setting, checking, and strength.

Lock gates.—The existing designs for the lock gates are of a preliminary character, having been perfected only so far as was necessary to ascertain the strains produced upon the anchorage. The curved form and great length as compared to the height, point, it would seem, to a gate constructed with top and bottom chords and heavy vertical frames diagonally braced, as the most economical form. A design for a gate of the above description is in progress.

Drawings and patterns.—The following drawings have been made during the year: General working drawings for the various portions of the south wall and west end of the north wall; detail drawings of the recesses, culvert piers, arch stones, and other special stones for the south wall and miter wall, including coping, working drawings for the erection of the upper gate anchorage, and for the snubbing hooks. Patterns have been made for the arch stones, miter-wall stones, wing wall, and special recess stones. The progress of construction is recorded each month on progress profiles and by photographs.

Gauge records.—Gauge No. 1 is located at the head of Colbert Shoals near the site of the proposed guard lock. Gauge No. 4 is below Bee Tree Shoals near the lift lock now under construction. Both gauges have been observed twice each day during the year. The maximum and minimum differences between the water level at the

* Not printed.

upper and lower lock sites for each month are given below. All observations have been referred to the datum plane of the lift lock:

Month.	Gauge observations.						Remarks.
	Maximum gauge.			Minimum gauge.			
	No. 1.	No. 4.	Difference.	No. 1.	No. 4.	Difference.	
1895.							
July	36.70	16.90	19.80	35	10.90	24.10	Reference of zero of gauge 1=33.70 feet.
August	37.10	17.50	19.60	35	10.90	24.10	Reference of zero of gauge 4=10 feet.
September	35.40	11.90	23.50	34.20	9	25.20	
October	34.20	9	25.20	34	8.40	25.60	
November	34.80	10.20	24.60	34.10	8.70	25.40	
December	37.90	20.30	17.60	34.30	9.30	25	
1896.							
January	37.20	17.60	19.60	35.20	11.50	23.70	
February	41.40	33.50	7.90	36.20	14.20	22	
March	40.50	29.50	11	36	13.60	22.40	
April	47.20	41.30	5.90	36	13.50	22.50	
May	36.60	15.50	21.10	35	10.80	24.20	
June	36.50	13.70	22.80	35	10.90	24.10	
Average	37.95	19.74	18.21	35	10.97	24.03	

MISCELLANEOUS.

Gate anchorage.—The parts of the anchorage that are to be embedded in masonry were received during last year. The anchor bars for the upper gate have been built into the south wall.

Snubbing hooks.—Nine snubbing hooks have been made and built into the south wall and four in the north wall.

Canvas dam.—An opening 180 feet long is left in the levee at the west end to admit the railroad tracks and wagon roads into the yards. When necessary for protection against high water it is closed by a canvas dam 180 feet long by 10 feet high. The dam has been placed in position twice during the past year, about six hours being the time required to erect it. The material used is 12-ounce duck. The greatest head to which it has been subjected is 39 inches.

Sand and cement.—One thousand eight hundred and twenty-one and four-tenths cubic yards of sand and 5,872 barrels of cement have been received.

The remaining miscellaneous work consisted in building and repairing levees, clearing landing for steamboats, destroying sunken barge at Riverton Wharf, unloading stone for contractor, unloading coal, sand, cement, and stone, pumping, moving derricks, ditching around lock pit and yards, maintenance of tracks and machinery, extending traveling crane track, sharpening and repairing tools.

There have been no accidents or injuries of magnitude either to the plant or any of the employees.

Twenty-nine days have been lost, including six legal holidays, as follows: Eleven from high water, two from failure of water supply, and ten from inclement weather.

The photographs * taken during June, 1896, illustrate the present condition of the lock walls.

Very respectfully, your obedient servant,

SYDNEY B. WILLIAMSON,
Assistant Engineer.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

APPENDIX G.

REPORT OF MR. F. B. WILLIAMS, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Chattanooga, Tenn., January 22, 1896.

CAPTAIN: I have the honor to submit the following report of work done by the "survey party below Riverton," under my charge, during the months of August, September, October, and November, 1895, and of the office reduction of notes of the same to date.

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* Not printed.

During the first part of August I made the trip from Riverton, Ala., to Haddox Ferry, Ky. (14 miles above Paducah), in a skiff, establishing temporary gauges about 30 miles apart. These gauges were read twice a day during the survey.

The survey party was ordered to report at Riverton, Ala., August 24. Two quarter boats were brought down from Muscle Shoals Canal for the use of the party. The party consisted of 33 members as follows: Chief of party, 3 transit men, 2 level men, 6 rodmen, 6 axmen, 7 boatmen, 1 recorder, 1 leadsman, 2 flagmen, 1 cook, 2 waiters, and 1 watchman.

The instructions were to carry out the general plan of previous surveys on the upper Tennessee and of the survey begun the year before, where especial attention had been paid to the bed of the river rather than to the banks. The organization of the party was the same as in 1894 under Lieut. James F. McIndoe, Corps of Engineers, United States Army. The topography of the banks from water s edge to top of bank was thoroughly taken by the transit and stadia method, but no elevations taken by vertical angles.

Cross sections of the bank were taken with a lock hand level. Topography of all bars and islands was taken in like manner. Nothing was taken back of the "top of bank" except that the general character, as to cultivated or wooded land, was ascertained and towns located.

Observations on Polaris were made at the beginning for true meridian and latitude with an ordinary transit. Continuous azimuth was carried and checked up from time to time by observations on Polaris or 51 Cephei. A system of check points, used on Mississippi and Missouri rivers, was also adopted to enable the transit men to carry their azimuths by long sights and to check one another. Two ordinary level parties, one on each bank, took frequent elevations of water surface, established bench marks, and obtained elevations of high and low water marks and gauges. These lines of levels were connected and checked by a river crossing every 3 to 5 miles, the limit of closure being 0.2 foot.

The soundings were made from the bow of a skiff with an octagon pole, up to depths of 13 feet and with a lead line for greater depths. The tenths were estimated and the readings given to the nearest tenth of a foot. A flagman on shore kept the skiff on line. The soundings were located by polar coordinates, the observer on the shore using a transit and reading the distance by means of a stadia rod held in the skiff. The distance between the ranges varied from 100 feet to 1,000 feet, depending on the depth of water, crookedness of channel, and obstructions. Especial care was taken on shoals, at the head of the islands, and at crossings. The character of the bottom was noted for each sounding and was usually gravel.

Borings were made in Big Bend Shoals and on Duck River Bar to ascertain the depth that could be easily penetrated into the bottom with a steel drill driven by hand.

The total amount of work done was as follows:

	Right bank.	Left bank.
Stadia lines run.....miles..	134.9	137.9
Number of courses.....	1,297	1,274
Level lines run .....miles..	130.7	132.4
Bench marks established	104	118

Number of ranges sounded, 1,048, covering a distance of 146.4 miles, including chutes. Number of borings, 19.

The party was disbanded November 23, 1895, having been in the field just three months. The greatest progress was made between September 20 and October 20, during which time a distance of 56 miles was covered. The sickness from malaria was almost unprecedented, especially in August and September, during the extreme warm weather, when it frequently happened that one-third or one-fourth of the party was unable to work. On the average there was one observer sick during the whole season.

The banks of the Tennessee River are exceedingly brushy and progress is difficult. The quarter boats were moved by hand, and, owing to the slow current and contrary winds, this often consumed much time.

The total cost of subsistence was $830.39, or an average of 27½ cents per man per day.

The amount paid out in salaries during the field season was about $4,010.77, including gauge readers' salaries and watchman's salary since the close of the survey; traveling expenses, $83.67; making total cost of survey about $4,925, or about $36.17 per mile.

In the office the latitudes and departures of the courses for one-half the distance have been computed, and the azimuths and distances corrected for nearly the whole survey, at a cost of about $380. There remains to be done, January 22, 1896, computation of the latitudes and departures of the remaining courses, reduction of level notes, reduction of all soundings to low-water stage, and making the map.

The survey closed at Fort Henry, Tenn., leaving from 60 to 65 miles to be surveyed to complete the survey of the river to Paducah, Ky.

Very respectfully, your obedient servant,

F. B. WILLIAMS,
Assistant Engineer.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

APPENDIX H.

REPORT OF MR. D. W. CHURCH, ASSISTANT ENGINEER.

ENGINEER OFFICE, UNITED STATES ARMY,
Chattanooga, Tenn., January 28, 1896.

CAPTAIN: I have the honor to make the following report on the survey and examination of the Tennessee and Ohio rivers in the vicinity of Livingston Point, Ky., made December 9 to 19, 1895.

The survey comprised the location of high and low bank lines and topography of the main shores and islands, the location of bar outlines, and the sounding of cross sections.

It covered a length of 9½ miles on the Ohio River and 3 miles on the Tennessee. The stadia survey was tied to a system of triangulation which followed the high banks of the Ohio River. The base from which the triangulation was started was measured on the large middle bar in front of Paducah, and another upon which the work was closed was measured on the long shore bar on the Illinois side, near the upstream limit of the survey. The difference between the calculated and measured lengths of the upper base was 0.4 of a foot.

The number of full cross sections sounded was 23. Four sections were made across chutes or sloughs, and 19 partial sections were sounded to determine the depths near shore along the revetted portion of Livingston Point. They extended 200 feet out from shore and were taken at intervals of from 200 to 300 feet on both the Ohio and Tennessee sides.

The survey notes have all been plotted and the completed maps are transmitted herewith.

A comparison of the partial sections taken around Livingston Point with those taken in 1893 by Mr. F. R. R. Smith shows that no important change has taken place since that time.

The stone revetment which covers Livingston Point for a length of about 3,000 feet from its lower end was found to be in fairly good condition throughout, and no trace could be found of the break which I reported to Captain Bingham March 30, 1895, after the examination of the work which I made at that time. The stage of the river in March was not a favorable one for a thorough inspection of the work.

The river was 27½ feet higher than in December and was flowing a few inches deep over the neck at the upper end of the dike. At the point where the revetment appeared to have given way the top of the bank was about 4 feet above water. The bank stood vertically and was slowly dropping in under the action of the current and waves. It is probable that at some previous high stage a heavy deposit had formed over the revetment, and that at the time I was there this deposit was being cut away.

At two or three places along the revetment the earth is exposed for a very small area, where the stone has been either displaced or removed.

The pile dike is also in need of slight repairs at one place, where a pile is broken. With these exceptions the whole work appears to be in good condition.

There is a cluster of bowlders or rocks about 100 feet out from the left shore of the Tennessee, on the line of the first cross section above the tow-head which showed above water in December.

Respectfully submitted.

D. W. CHURCH, *Assistant Engineer.*

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

APPENDIX I.

REPORT OF MR. W. A. M'FARLAND, ASSISTANT ENGINEER.

UNITED STATES MUSCLE SHOALS CANAL, ALABAMA, *June 30, 1896.*

CAPTAIN: I have the honor to submit the following report of work done in connection with operation and care of the United States Muscle Shoals Canal during the fiscal year ending June 30, 1896:

During this time the canal has been continuously open for the passage of steamboats, repairs to plant being as a rule made at such times as would not interfere with traffic; the only exception was during the construction of dry-dock abutments (March 27), when the steamer *City of Chattanooga* was delayed about three hours.

No serious trouble has been experienced with the maneuvering machinery, but it is probable that a breakdown may occur unless extensive repairs be made during the ensuing year to the hydraulic plant at Lock A.

The various locks, buildings, grounds, embankments, and the railway have been cared for, and a regular daily patrol maintained along the embankments of the lower division for the purpose of detecting leaks. No serious washout has occurred during the past year.

On the Upper or Elk River Division no work has been done other than that of ordinary maintenance.

Following is a general statement of work done on the Lower or Big Muscle Shoals Division:

A saw and planing mill building of 40 by 90 feet ground plan has been built just above Lock 6, motive power and machinery placed, and mill put into operation. Power is supplied by a 24-inch De Loach turbine under a working head of 13 feet.

The machines now in place are a De Loach sawmill, No. 2, with 60-inch bottom saw and 30-inch top saw; a J. A. Fay & Co.'s 6 by 24 inch six-roll wood planer, small circular saw for resawing, and swinging cut-off saw for cutting up slabs, etc. Power is transmitted by steel bevel gears from vertical wheel shaft to horizontial line shaft, and thence by belting and jack shaft to the several machines; all shafting is below the floor of the mill.

A spur track from the canal railway has been extended to the rear of the mill, where one endless-rope conveyor delivers dust and other refuse into dump cars, which are subsequently emptied into Shoal Creek.

The construction of a dry dock, to be 70 by 150 feet in plan, was begun on the north side of the canal between Locks 6 and 7; 2,367 cubic yards of stiff clay and stone were excavated from the site by dredging and 355 cubic yards by hand; 89 cubic yards of coursed rubble masonry laid in Portland cement mortar for abutments of gateway; 77 cubic yards of earth tamped in behind abutment; 30 linear feet of drainage ditch cleaned out and bull-pointed; work remaining to do is construction of sills, gate, and drain culvert.

Miscellaneous work of repair and construction in machine shop, carpenter shop, and blacksmith shop has been carried on continuously during the year. Following is a statement of the chief items of work done:

Machine and blacksmith work.—Small vertical engine (5 by 6 inches) completely rebuilt and fitted with Stevenson reverse gear, for use with multiple screw steamboat; 8 four-blade 16-inch pitch propellers, 9 inches diameter, made for same, complete with shafts and bearings; boiler placed in boat and necessary connections made.

Four-horsepower engine of naphtha launch overhauled and cleaned and new three-bladed bronze propeller fitted to shaft; log-haul winch with friction clutch and all fittings made complete for use in sawmill; small wood shaper made complete for use in wood-working shop; iron work made for rip and cut-off saw for use in mill; iron bridge built under railway across mill flume; hydraulic fin and segmental cylinder from Lock A repaired; slight repairs made to culvert valves at Locks 2 and 3, and to drop gates at Locks 5, 6, 7, and 9; lifting tongs and ladle carrier made for use in brass foundry; throttle valve of locomotive No. 4 repaired and new truck wheels put under locomotive No. 5; three headlights overhauled; made six sets of stem and corner bands for use on barges; two shackle bars made for use at ship yard; 178 dowel pins made for locking beams on Shoal Creek Bridge; tool rest for wood lathe; traveling crane erected in storage building; steel type frame made for map lettering apparatus; tap die and die stock made for cutting 1¼-inch bolts and nuts; welded link on ratchet chain for *Colbert* and made iron work for two sets of davits as designed by Capt. Edmund Gray.

For steamer *McPherson:* Overhauled capstan engines; drilled and tapped cylinders for indicators; lengthened rudder posts and made brass hand rings for use in engine room.

On dredge *Harwood:* Overhauled and lined up machinery and made new main shaft for main engines.

On steam flat fitted reverse lever and connecting link, repaired steam valve, made ring and buttons for signal bell, and turned up rope pulley.

Made steel propeller shaft for naphtha launch; overhauled engine in machine shop; made two sets of dies for bolt machine; made braces for snag boat, four bits for wood planer, and mandrel for grindstone; fitted frame for cut-off saw; repaired miter box; shanked six ship bits; made a knife grinder; made heater for "U. S." brand and ringbolt for ratchet of *Colbert*; made bolts, sharpened tools, etc.

Carpentry.—Sawmill building, 40 by 90 feet in plan, with 8-foot posts and trussed roof, built complete, except siding, windows, and doors; penstock and flume erected; lumber shed, 24 by 30 feet in plan, with 12-foot posts and shingled roof, built for storage of finished lumber; small dry kiln (steam heated) made for drying lumber; house built over brass furnace; track for traveling crane erected in storage building; house (16 by 28 feet) built for protection of naphtha launch; built additional sleeping quarters on second floor of laborers' building; rebuilt entrance gates to grounds at Lock 6; new bridge erected over branch in United States reservation; eight wooden valve covers made for upper division; renewed gate spar platforms at Locks 2, 3, and 8; repaired walk ways on gates at Locks 7, 8, and 9; refitted woodwork of naphtha launch; made frame and sliding table for cut-off saw in mill; main engine cylinders of Bucyrus dredge relagged; platform built around bucket ladder; derrick made for tool car; made five small drawing boards, two pamphlet cases, and four boxes for books; drill case for machine shop and instrument case for physical instruments; ice box for survey party; Prony brake for testing turbine; made seven 12-foot tripods and model for same, boom for derrick car, pair of trestles for drawing board, and sash for snag boat; laid floor at sawmill; put decking on boat landing at Lock 6; made window frames for mill, steering oars for sand barges, and 50 rollers for use at Riverton. Repairs to U. S. S. *Colbert:* Main deck, including deck beams and stanchions, renewed throughout; stay chains put in; flagstaff made; wheel repaired; new roof put on; landing stage built; broken starboard gunwale repaired; cylinder timbers strengthened.

Snag boat Weitzel.—"A" frame made and erected and deck patched; this boat was subsequently abandoned and broken up as being unworthy of repair.

Dredge Harwood.—Spud casings repaired, bolted, and calked.

Steamer McPherson.—Bulkhead built forward of engines; shackle blocks put down; two rope reels made; rudders repaired; covering built over steam pipe on roof; bunks built.

Painting.—Two painters employed continuously in repainting United States buildings and other property.

In addition to the items above enumerated a great number of minor repairs were made to locks, buildings, cars, locomotives, boats, machinery, etc.

Dredging was done as follows:

	Cubic yards.
On section 4, mud	575
On section 10, clay, stone, and mud	1,016
On section 13, mud	555
On sections 15, 16, mud	1,155
On section 21, mud	885
On section 22, mud	1,077
Below Lock 9, sand and gravel	250
Total from canal	5,513
From site of dry dock, stone and clay	2,367
Total amount dredged	7,880

The dredge (elevator type, *Bucyrus*) was employed in 1895 from July 15 to 31 and from December 26 to 31, and in 1896 from January 2 to 31 and on February 5 and 11 on canal work, and on dry dock from November 23 to December 20, 1895; when not at work the crew was laid off with the exception of the "runner," who was employed on miscellaneous work about the dredge.

Masonry and stonework.—Twenty cubic yards ashlar masonry built in flume for sawmill, natural cement (Louisville) mortar used; 33 cubic yards coursed rubble masonry laid in tail race; mantels and grates reset in lockkeepers' houses at locks A, B, 2, 3, 4, 5, 6, and 9; 22 cubic yards rubble masonry laid in locomotive pits, and 15 cubic yards concrete flooring put in sheds; 25 cubic feet stone cut for foundation of 25-inch engine lathe; repointed lock walls at Locks 6 and 7; 2 cubic yards masonry laid as foundation under wood planer.

Miscellaneous.—Two hundred and twenty-four cubic yards earth fill placed behind retaining wall below Lock 4, and track restored; 175 cubic yards earth used in grading on south side of Lock 4; 60 cubic yards earth used in grading at Lock 2; 80 cubic yards earth on south side and 126 cubic yards on north side used in grading at Lock 6; 127 cubic yards earth distributed in section 27; 2 barges loaded with 125 cubic yards sand and floated to Riverton; eight slight leaks through embankments on sections 6, 7, 8, 9, 12, and 28 repaired.

Five hundred and thirty linear feet of ditch of 4 square feet mean section dug to

drain seepage water from bottom land on section 25. Section gang employed on railway. Logging gang employed in cutting and hauling timber for use in general repairs. Locomotive employed in towing and miscellaneous work.

WORK UNDER APPROPRIATION FOR GENERAL IMPROVEMENT.

Spur dam below Lock 9.—1,091 cubic yards of stone quarried, and 3,437 cubic yards of stone placed in dam, making total length of 360 feet to a height of 2 feet above mean low water; cost of work, $1 per cubic yard in place, including all expenses. For a detailed report of this work I would respectfully refer to my letter dated November 16, 1895, to Lieut. James F. McIndoe, Corps of Engineers, United States Army.

Shipyard.—Two deck barges (Nos. 212 and 213), 100 by 25 feet, built complete; also one flatboat for use as low-water steamboat, size 10 by 45 feet. Barge No. 208, 80 by 20 feet, rebuilt. Barge No. 209 partially repaired; 3 skiffs, 1 calking flat, and 1 30-foot flat, for handling drift at Lock 1, built complete; barge No. 202 (15 by 59 feet 6 inches) rebuilt.

Rake molds made for new 100-foot snag boat and 12 gunwale timbers framed, scarfing and flooring cut, bottom plank and decking dressed. Rakes and new sides put in survey quarter boat.

The following statement shows cost of lumber sawed at mill:

Total timber purchased, 124,742 feet	$431.10
Average cost per 1,000 purchase	3.46
Average cost per 1,000 cutting and hauling	3.75
Average cost per 1,000 sawing	2.50
Total average per 1,000	9.71
Sawed 117,533 feet, at $9.71	1,141.25
Depreciation of plant (six months)	200.00
Incidental expenses, repairs to machinery and contingencies (10 per cent)	114.12
Total	1,455.37
Market price of lumber (average), $20.	
Cost for 117,533 feet	2,350.66
Saving to United States	905.29

or 38½ per cent.

The traffic record of Muscle Shoals Canal for year ending June 30, 1896, is inclosed.

Very respectfully, your obedient servant,

W. A. McFARLAND,
Assistant Engineer.

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

Commercial statistics of Tennessee River above Chattanooga, Tenn.

Articles.	Year ending December 31—				Estimated value, 1895.
	1892.	1893.	1894.	1895.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	
Grain	6,939	25,911	55,116	45,433	$765,546.05
Iron ore	13,365	11,988	14,567	66,347	79,616.40
Lumber	102	3,464	7,957	14,995	93,718.75
Sand	5,150	1,763	1,225	1,500	1,005.00
Tan bark	412	800	27	.....	.....
Flour	271	644	1,844	1,495	52,325.00
Logs and wood	50,000	225	40,000	82,680	248,040.00
Live stock	226	528	1,089	1,249	78,062.50
Railroad ties	.....	88	.....	1,000	2,500.00
General merchandise	14,716	25,615	38,579	34,011	3,060,990.00
Cotton	.....	.....	14	27	3,780.00
Cotton seed	6	.....	400	.....	.....
Coal	.....	.....	.....	7,105	14,210.00
Hay	.....	.....	.....	1,827	14,616.00
Shingles	.....	.....	.....	5,250	105,000.00
Brick	.....	.....	.....	2,337	8,179.50
Total	91,187	71,026	160,818	265,256	4,527,589.20

Number of passengers transported (1895), 16,295.

Commercial statistics between Chattanooga, Tenn., and Decatur, Ala.

Articles.	Year ending December 31—				Estimated value, 1895.
	1892.	1893.	1894.	1895.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	
Lumber	3,113	58,525	12,738	22,290	$139,312.50
Cotton	3,038	190	4,095	3,970	555,800.00
Live stock	621	197	921	234	14,625.00
Grain	7,396	1,798	7,559	13,716	231,114.60
Flour	1,054	342	3,288	3,874	135,590.00
Cotton seed	285	24	1,078	1,083	16,245.00
General merchandise	10,036	5,578	15,001	9,465	851,850.00
Logs and wood	45,755	6,090	122,011	1,287	3,863.00
Iron ore	2,250	4,581	6,664	46,610	55,932.00
Staves	5,272	.....	.....	66	181.50
Peanuts	.....	.....	.....	25	3,000.00
Coal	.....	.....	.....	2,056	4,112.00
Hay	.....	.....	.....	47	376.00
Tan bark	.....	.....	.....	1,150	69,000.00
Sand	.....	.....	.....	8,984	6,019.28
Stone	.....	.....	.....	2,500	12,500.00
Total	78,820	77,325	173,355	117,357	2,099,520.88

Number of passengers transported (1895), 9,016.

Commercial statistics between Florence, Ala., and Paducah, Ky.

Articles.	Year ending December 31—				Estimated value, 1895.
	1892.	1893.	1894.	1895.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	
Iron, pig	6,970	14,454	6,664	49,384	$493,840.00
Staves	3,986	4,141	2,251	27,296	75,064.00
Lumber	24,742	104,000	20,028	91,324	507,775.00
Cotton	6,105	1,837	4,437	16,317	2,284,380.00
Peanuts	4,649	2,029	640	8,910	1,069,200.00
Live stock	2,189	3,090	2,238	4,250	265,625.00
Hoop poles	5,699	124	880	68,052	340,260.00
Grain	18,249	12,121	9,990	24,283	409,168.55
Flour	6,073	4,352	4,510	6,600	231,000.00
Cotton seed	995	24	1,076	.....	.....
Sand	2,353	701	4,922	14,437	9,672.79
General merchandise	36,114	28,177	22,089	100,072	9,006,480.00
Logs	71,336	30,300	192,012	112,432	562,160.00
Railroad ties	46,749	139,203	37,175	194,501	398,727.50
Coal	.....	.....	.....	92,335	184,670.00
Stone	.....	.....	.....	3,666	18,330.00
Tan bark	.....	.....	.....	34	2,040.00
Tobacco	.....	.....	.....	310	74,400.00
Wood	.....	.....	.....	34,060	34,060.00
Total	236,209	344,553	308,914	960,959	15,966,852.84

Number of passengers transported (1895), 47,558.

The great increase in tonnage for 1895 may be due in part to a more careful collection of statistics, although it is by no means certain that even this report includes all the commerce on this section of the river. Towboats frequently come into the Tennessee River and take out large tows, but make no report. Large quantities of logs are also rafted without the use of a steamboat, and it frequently happens that no record of this can be obtained.

List of steamboats (stern-wheel) plying on the Tennessee River above Chattanooga, Tenn.

Name.	Length.	Breadth.	Depth.	Net tonnage.
	Feet.	*Feet.*	*Feet.*	
C. M. Fouche	93	14	2.	61.12
J. C. Warner	142	31.6	4.6	201.05
J. W. Bussell	76	9	2.8	24.60
Lucille Borden	86	14	2.5	55.32
Oliver King	60	8	2.6	29.30
Rockwood	130	25.6	4	150.52
R. T. Coles	118	24.6	4.2	134.91
Tallassee	60	12	2	22.16
Kingston	55	11	3	37.80
Onega	104.6	18	2.5	74.77
Ocoee	51.5	12.5	1.6	19.18
Wyeth City	120	21.5	4.8	138.96
Clinton B. Fisk	100	18	3.4	78.89
Key City	80	15	3.2	59.45
Maud	79	16.5	3.2	23.30
J. P. Kindrick	112	20	3.7	125.71
Ruth Dodd	37.5	7	2.8	11.12
Volette	45	8	3	15.50
John A. Hart	41	7	2.1	5.63
Wm. Towle	90	16	3.5	63.86
E. P. Dawson	60	10	2.8	29.30
Telephone	93	19	2.6	97.47
Mamie Bauer	73	17.5	3.0	45.36
Lora	70	12	2.5	22.16

List of steamboats (stern-wheel) plying on the Tennessee River below Chattanooga, Tenn.

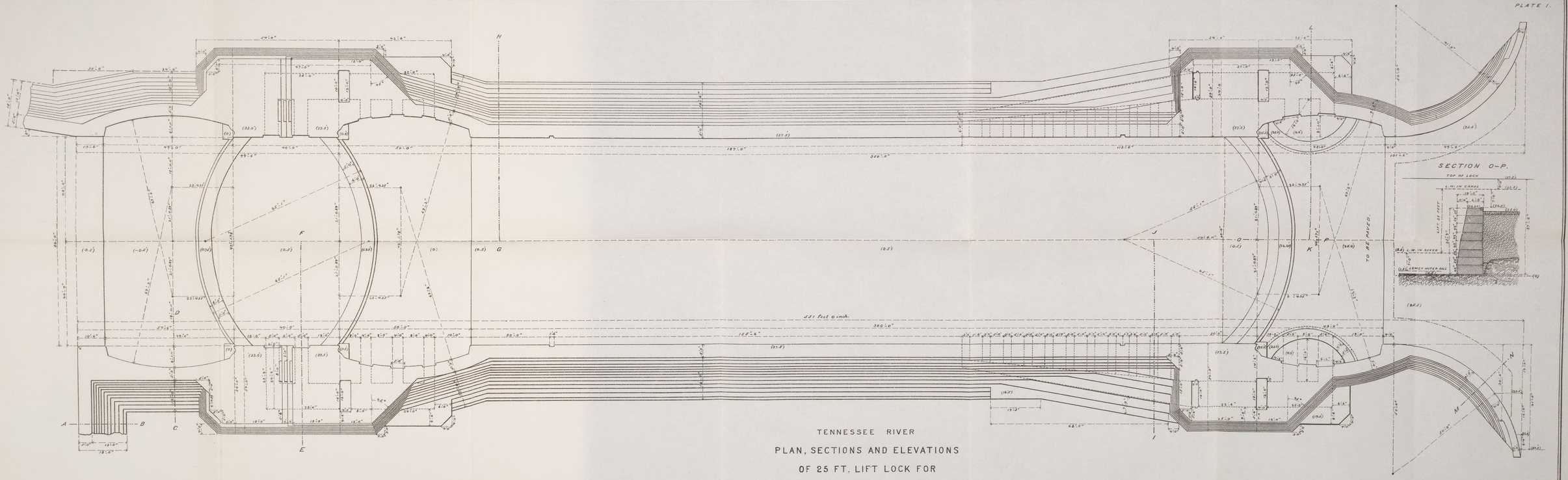
BETWEEN CHATTANOOGA, TENN., AND DECATUR, ALA.

Name.	Length.	Breadth.	Depth.	Net tonnage.
	Feet.	*Feet.*	*Feet.*	
Maud	79	16.5	3.2	23.30
B. F. Young	120	24	4	160.68
R. C. Gunter	153	28	4	337.30
Wyeth City	120	21.5	4.8	138.96
R. T. Coles	118	24.5	4.5	134.91
City of Chattanooga	134	27.8	3.6	167.60
J. P. Kindrick	111	20	3.5	128.71
Rockwood	130	25.6	4	150.52
A. J. Duncan	150	32	4	460
Walter R. Love	112	18	3	80.14
Luke Pryor, jr	.....	.....	2	124.26

BETWEEN FLORENCE, ALA., AND PADUCAH, KY.

	Feet.	*Feet.*	*Feet.*	
City of Savannah	190	32	5	335.50
City of Sheffield	180	32	5.5	750
City of Paducah	183	37	5.25	700
W. S. Nesbit	212	36	6.5	680
Clyde	185	33	6	580
A. S. Willis	.....	.....	.....	133
Gus Genin	120	20	4	130
C. Smith	132	29	3.5	350
City of Chattanooga	134	27.8	3.6	167.60
J. P. Kindrick	111	20	3.5	128.71
Edwin Wood	80	12	4	32.97
I. N. Hook	110	19.2	3	55.95
Dick Clyde	96	17.4	3.9	76.84
R. A. Speed	124	22	4.2	140.57
Al. Martin	112	23.6	4	96.68
Maggie Belle	95.6	18.4	3.6	52.81
Rockwood	130	25.6	4	150.52
A. J. Duncan	150	32	4	460
B. F. Young	120	24	4	160.68
R. C. Gunter	153	28	4	337.30
Sentinel	83.6	17.6	3.25	35.96
Allen J. Duncan	149	31	4	318.46
Wyandotte	91	18	3	65.94

PLATE I.



TENNESSEE RIVER

PLAN, SECTIONS AND ELEVATIONS

OF 25 FT. LIFT LOCK FOR

COLBERT SHOALS CANAL.

RIVERTON, ALA., JUNE 30. 1896.

Scale in feet:

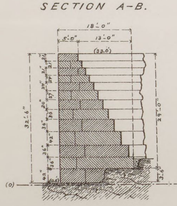
16 12 8 4 0 16 32 48

TO ACCOMPANY ANNUAL REPORT OF 1896.

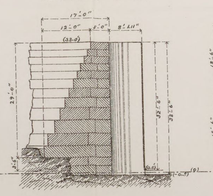
Dan C. Kingman

LIEUT. COLS. OF ENGRS., U.S.A.

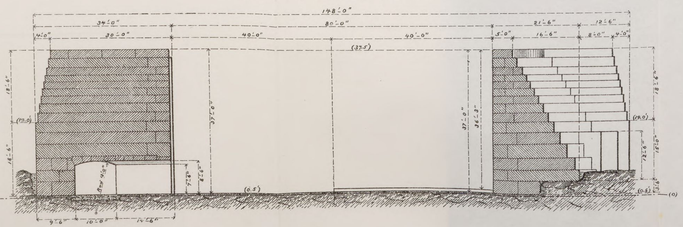
SECTION A-B.



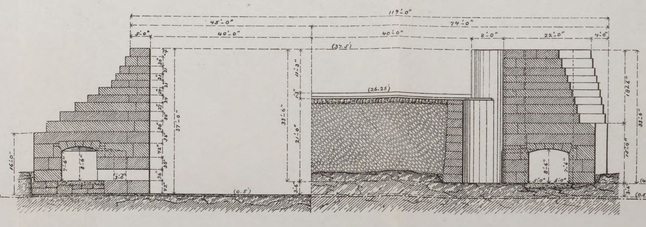
SECTION C-D.



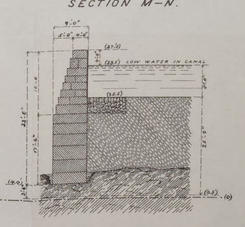
SECTIONS E-F AND G-H.



SECTIONS I-J AND K-L.



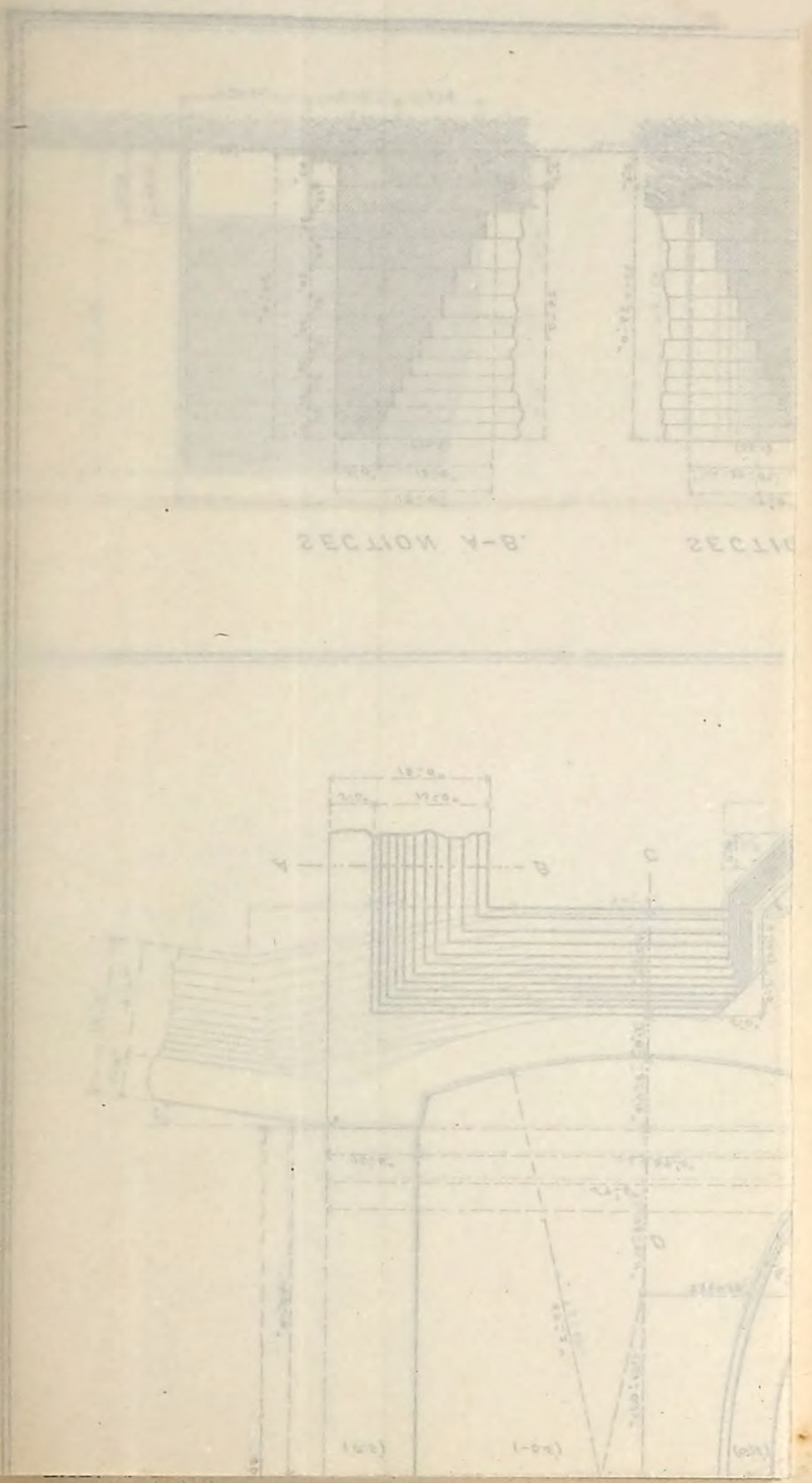
SECTION M-N.



J. Shutting del.

ARENS & GRAHAM, PHOTO-ENG. WASHINGTON, D.C.

Eng 54 2

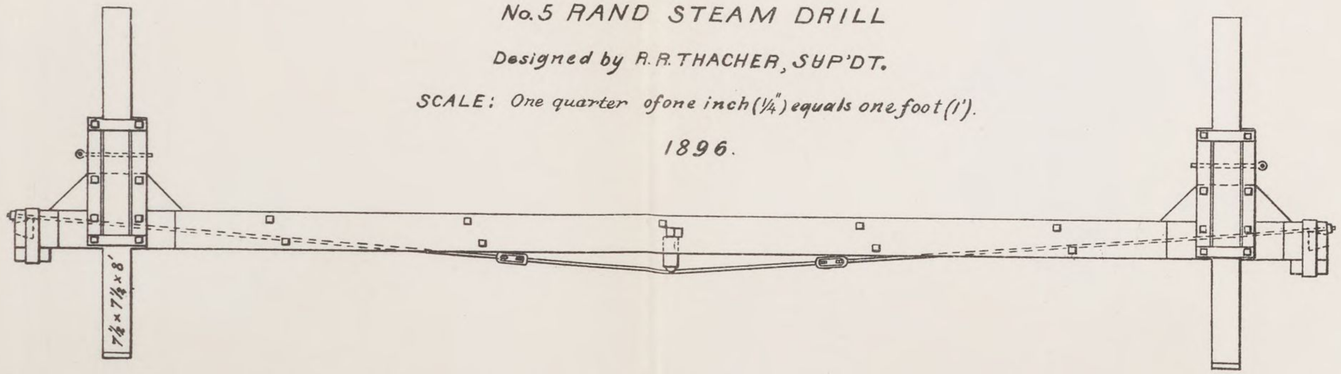


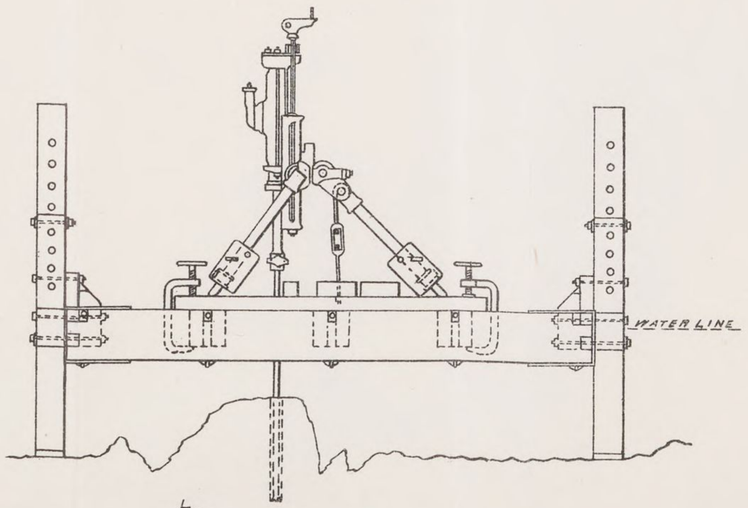
DRILLING RAFT AND ATTACHMENTS
FOR
No. 5 RAND STEAM DRILL

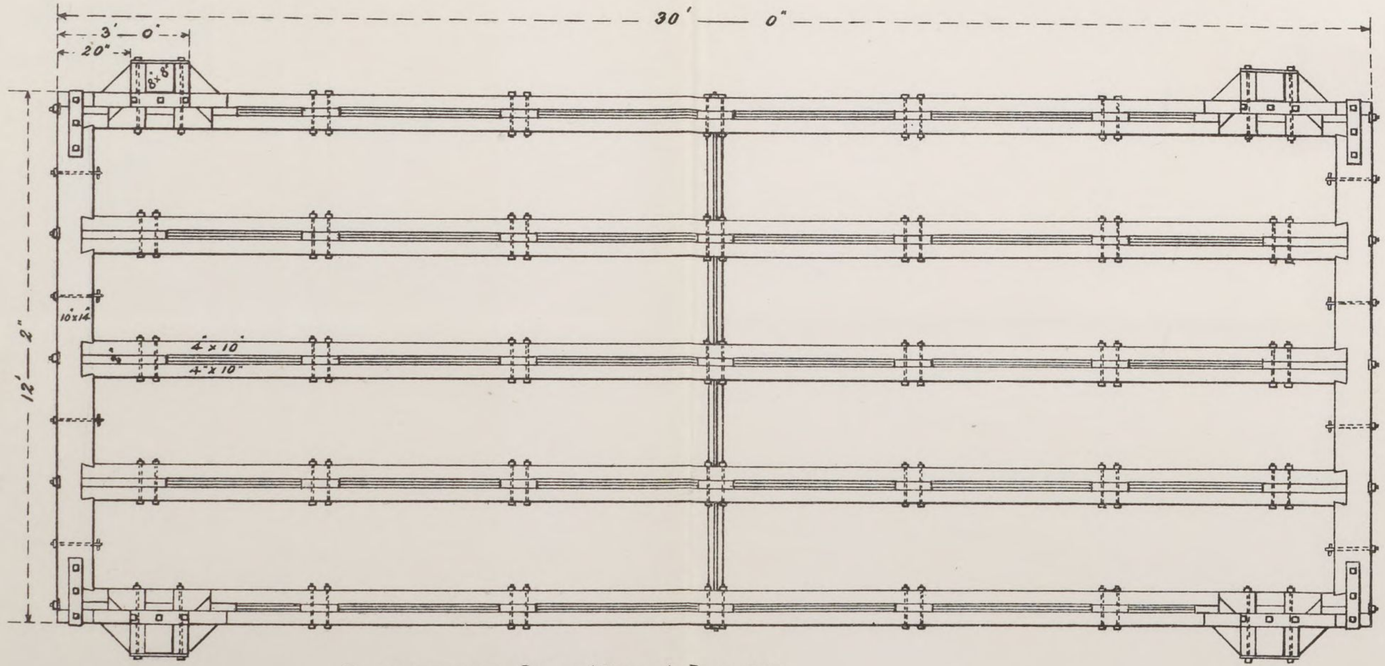
Designed by R. R. THACHER, SUP'DT.

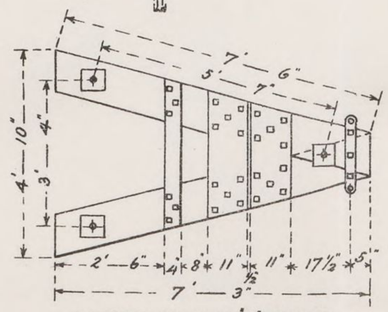
SCALE: One quarter of one inch (¼") equals one foot (1').

1896.









GROUND PLAN OF "A" FRAME.

LIST OF MATERIALS.

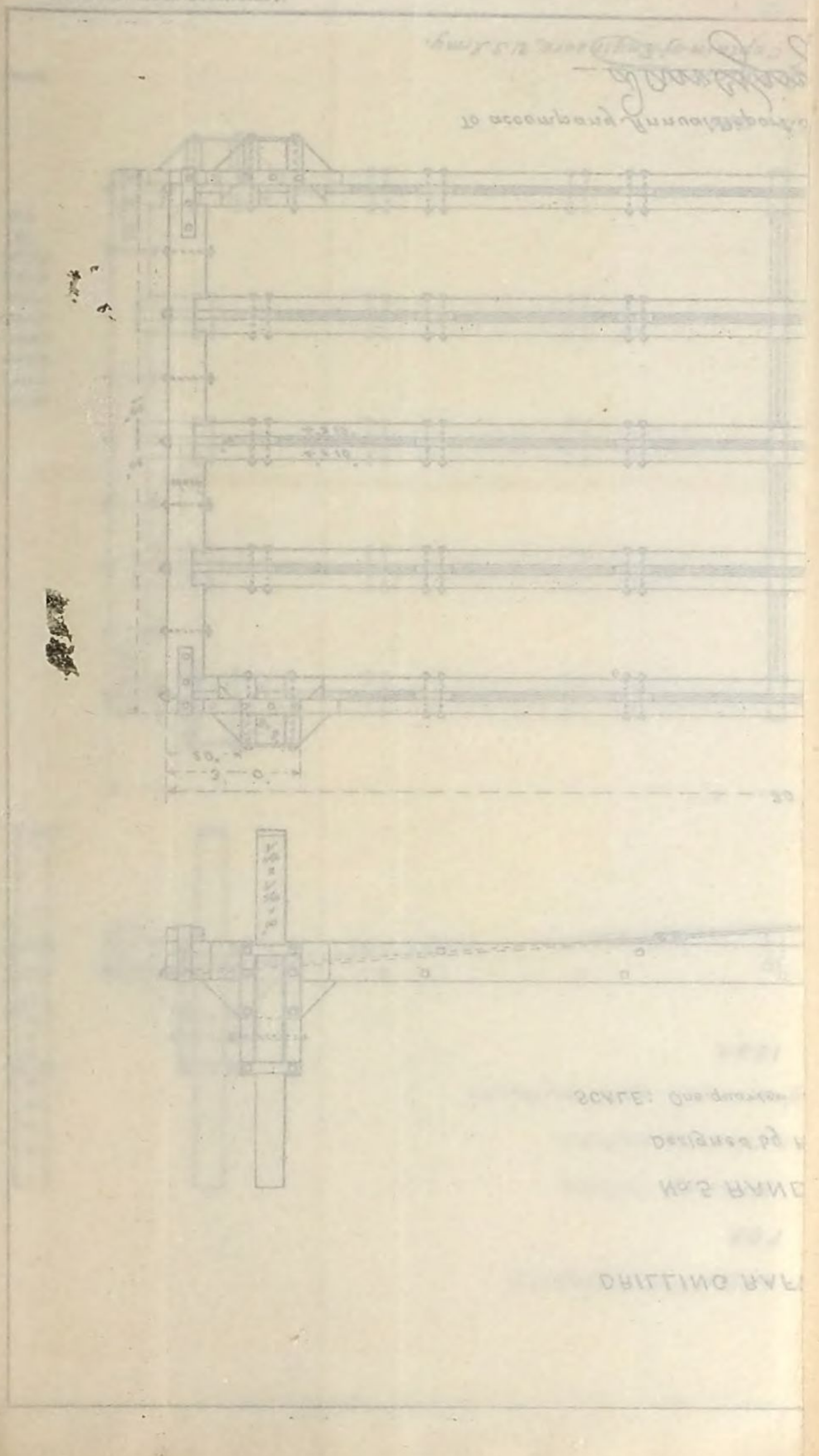
	Pcs.					Pcs.		
MAIN TIMBERS	10	4"×10"—30'	1000	PINE	HOG CHAINS Lin. Ft.	160	¾"	0"
HEAD BLOCKS	2	10"×14"—12'	280	OAK	CENTER BOLT	12	¾"	0"
CENTER CROSS TIMBER	1	4"×8"—12'	32	PINE	CORNER BANDS	4	½" × 4"	
SPUD GUIDES	2	4"×8"—12'	64	"	SPUD GUIDE PLATES	12	½" × 3"	
SPUDS	4	8"×8"—8'	170	"	SPUD PINS	8	1¼"	0"
CORNER BLOCKS	1	6"×10"—16'	80	"	BOLTS No.	28	¾" × 19"	
SIDE BRACES FOR SPUDS	1	4"×10"—12'	40	"	"	8	¾" × 12"	
BLOCKING	4	2"×10"—10'	66	"	"	72	¾" × 10"	
"A" FRAME	3	4"×12"—8'	96	OAK	"	8	¾" × 9"	
TOTAL FT. B. M.	1	4"×4"—4'	6	"	"	29	⅝" × 8"	
			1833		RING BOLTS	8	¾" × 12"	
					BOLT ENDS	12	¾"	0"
					TURN BUCKLES	11	¾"	
					SADDLES C. IRON	5		
					PLATES FOR "A"	3	6"×6"×¼"	
					LAG SCREWS	24	½" × 5"	

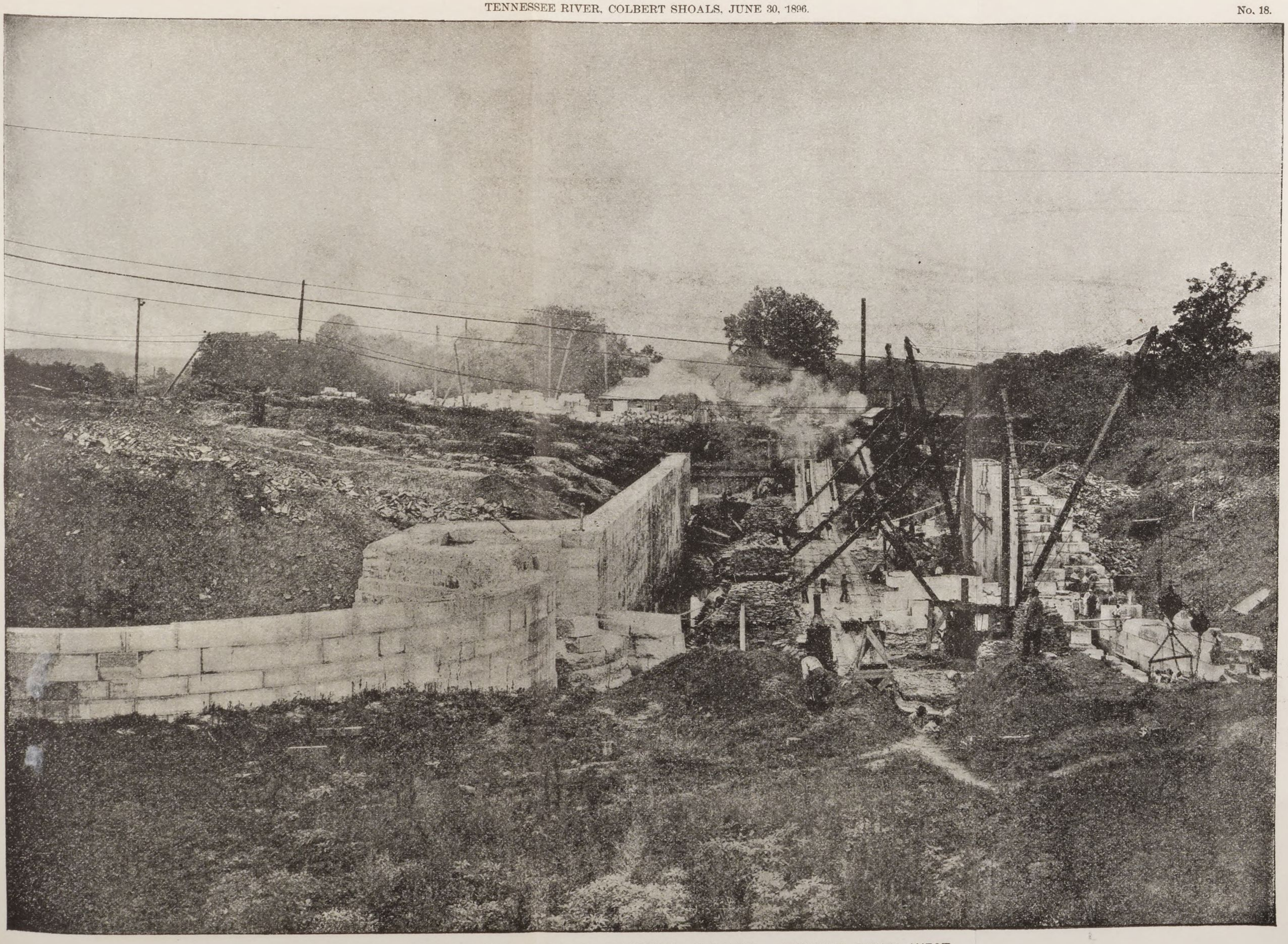
To accompany Annual Report June 1896

Dan C. Kingman

Captain of Engineers, U.S. Army.

ANDREW B. GRAHAM, PHOTO-LITHO. WASHINGTON, D.C.





GENERAL VIEW OF LIFT LOCK AT RIVERTON, ALABAMA. LOOKING DOWN—WEST.

List of steamboats (stern-wheel) plying on the Tennessee River, etc.—Continued.

BETWEEN FLORENCE, ALA., AND PADUCAH, KY.—Continued.

Name.	Length.	Breadth.	Depth.	Net tonnage.
	Feet.	*Feet.*	*Feet.*	
Corinne	46.5	8.4	4.6	13.39
Annie Barnes	53	12	3	9.16
Frank Burnett	50.6	9.2	2.8	7.61
Clayton H. Webb	112.9	24.7	3	98.7
Mary N	69	14	3	36.54
Wm. Towle	90	16	3.5	63.86
Montezuma	49	12	3.5	16.19
Lamasca	85	15	3	37.73
Kenton	106.2	33	5.2	153.08
Luke Pryor, jr	.....	.....	2	124.26
John D. Lewis	148.2	28.2	4	266.41
Emma Cooper	95	25	3.3	79.10
Penguin	80	16.6	3.4	60.68
Bettie Owen	137	39.9	4	189.34
Edgar Cherry	152	27.4	5	266.48
Tug Ida	80.5	14.8	7	37.73
George W. Parker	266	46.5	7	995.16
Spread Eagle	224.5	33.8	5.7	528.34
Artemus Lamb	140	36	4	176.73
Grace Morris	100	20	3.6	78.88
John L. Lowry	108	16	3.6	54.15
Fred Nellis	96	19	4	57.17
John Barrett	124.8	31	4	187.23
Josie	146.2	28.6	2.6	233.70
City of Quincy	130.7	25.8	6	169.01

B B 2.

OPERATING AND CARE OF MUSCLE SHOALS CANAL, TENNESSEE RIVER.

The Muscle Shoals Canal, which had been in course of construction since 1875, was formally opened to public traffic November 10, 1890.

The canal consists of two sections, known as the Elk River Division and the Muscle Shoals Division, being named thus from the shoals of the same names on the Tennessee River around which the two sections were constructed.

The Elk River Division is 1.5 miles long, not less than 100 feet wide, and has two locks, known as Locks A and B, each 60 by 300 feet, with a total lift of 23 feet.

The Muscle Shoals Division, beginning about 8 miles below Lock B, is 14.5 miles long, from 70 to 100 feet wide, and has been constructed by rebuilding and enlarging the old canal built for the United States by the State of Alabama, 1831–36. This old canal was used for one season, but the obstructions in the river above and below limited navigation to certain stages of the water; hence it was operated for one year only, after which, no funds being appropriated for its maintenance, it was disused and fell into decay.

The lower division of the canal contains nine locks of the same dimensions as those in the upper division, viz, 60 feet wide and 300 feet long, with a total lift of 85 feet.

During the past fiscal year the canal was kept in working order and no delay in traffic occurred, except in one instance during the construction of the dry dock abutments, when the steamer *City of Chattanooga* was delayed about three hours.

The locks, buildings, and grounds were cared for and kept in good condition; the entire line of embankment was patrolled daily for the purpose of detecting leaks; no serious washout occurred.

Work done during the year was as follows:

Upper Division (*Elk River*).—This division consists of an upper pool formed by a rock-fill dam extending from the lower end of Browns Island to Lock A, a mile of canal trunk between Locks A and B, and a dredged channel below lock B extending to channel in Gilchrists Chute. Total length, about 5 miles.

No work was done other than that of ordinary maintenance and keeping the channel above Lock A clear of drift and logs.

No serious trouble was experienced with the maneuvering machinery; but it is probable that a breakdown may occur, unless extensive repairs be made during the ensuing year to the hydraulic plant at Lock A. Such a breakdown would not, however, interfere with the use of the lock, since it can be readily operated by hand.

Lower Division (*Muscle Shoals*).—This division consists of an upper pool half a mile long, formed by extension of canal embankment above Lock 1, and of eight intermediate pools and nine locks, numbered from 1 to 9, beginning at the upper end. Total length, 14.5 miles. Total lift, 85 feet. Maximum single lift, 13 feet at Lock 6. Size of locks, 300 feet long between hollow quoins by 60 feet clear width.

A canal railway extending the whole length of this division is used in towing barges and in general work of maintenance.

Dredging during the year ending June 30, 1896:

	Cubic yards.
Section 4, deepening, mud	575
Section 10, deepening, clay, stone, and mud	1,016
Section 13, deepening, mud	555
Section 15–16, deepening, mud	1,155
Section 21, deepening, mud	885
Section 22, deepening, mud	1,077
Below Lock 9, deepening, sand and gravel	250
Total from canal	5,513
From site of dry dock, stone and clay	2,367
Total dredged	7,880

The dredge is of the Bucyrus elevator type, having a chain of twenty-four buckets, each of 5 cubic feet capacity. It was engaged on canal work from July 15 to 31, from December 26 to 31, 1895, from January 2 to 31, and on February 5 and 11, 1896; on excavation for dry dock from November 23 to December 20, 1895. While the dredge was not at work the crew were laid off with the exception of the "runner," who was employed on miscellaneous work about the dredge.

A large amount of repair and construction work was done at the canal shop near Lock 6 during the year, of which the principal items are as follows:

Machine and blacksmith shop.—A small verticle engine (5 by 6 inches) completely rebuilt and fitted with Stevenson reverse gear, for use with multiple screw steamboat; eight four-blade propellers, of 16 inches pitch and 9 inches diameter, complete with shafts and bearings, made for same boat; boiler placed in the boat and the necessary connections made.

The engine (four horse-power) of naphtha launch overhauled and cleaned, a new steel shaft made, and a new three-bladed propeller fitted to shaft; log-haul winch with friction clutch and all fittings complete made for use in saw mill; iron work for rip and cut-off saw made for use in mill; small wood shaper made complete for use in wood working shop; iron bridge built under railway across the mill flume.

Hydraulic fin and segmental cylinder from Lock A repaired; culvert valves at Locks 2 and 3, and drop gates at Locks 5, 6, 7, and 9 repaired; anchor rods of lower gates at Lock 3 repaired; throttle valve of locomotive No. 4 repaired and new truck wheels put under locomotive No. 5; three head lights overhauled; traveling crane erected in storage building.

Lifting tongs and ladle carrier made for use in brass foundry; six sets of stern and corner bands made for use on barges; two shackle-bars made for use at shipyard; 178 dowel pins made for locking the beams on Shoal Creek Bridge; tool rest made for wood lathe; steel frames made for holding type of map-lettering apparatus for Chattanooga office; tap, die, and die stock made for cutting $1\frac{1}{4}$ inch bolts and nuts.

On steamer *Colbert*, welded a link and made a ring bolt for ratchet chain and made and erected two sets of iron davits. On steamer *McPherson*, overhauled capstan engines, drilled and tapped cylinders for indicators, lengthened rudder posts, and made brass hand rings for use in pilot house. On dredge *Harwood*, overhauled and lined up the machinery and made a new main shaft for the main engines.

Engine in machine shop overhauled; two sets of dies made for bolt machine; four bits made for wood planer; braces made for snag boat; mandril made for grindstone, etc.

Tools and machinery repaired and kept in good condition throughout the year.

Carpenter shop.—A sawmill building, 40 by 90 feet in plan, with 8-foot posts and trussed roof built complete except siding, windows, and doors; a penstock and flume erected for turbine of sawmill; a lumber shed, 24 by 30 feet in plan, with 12-foot posts and shingled roof built for storage of finished lumber; small dry kiln (steam heated) made for drying lumber; house built over brass furnace; house (16 by 28 feet) built for protection of naphtha launch; additional sleeping quarters built on second floor of laborers' building.

Track for traveling crane erected in storage building; entrance gates to United States reservation at Lock 6 rebuilt; new bridge erected over branch in reservation; eight wooden valve covers made for upper division; gate spar platforms at Locks 2, 3, and 8 renewed; walk ways on gates at Locks 7, 8, and 9 repaired.

Frame and sliding table made for cut-off saw in sawmill; derrick made for tool car and boom for derrick car; five small drawing boards, one pair of trestles, two pamphlet cases, and five boxes for books made; drill case made for machine shop and instrument case for physical instruments; ice box made for survey party; "prony" brake made for testing the turbine.

On steamer *Colbert*, renewed main deck throughout, including deck beams and stanchions; put in stay chains; made new flagstaff; repaired the wheel; put on a new roof; repaired starboard gunwale, strengthened the cylinder timbers, and built a landing stage. On snag boat *Weitzel*, made and erected an "A" frame and patched the deck. On dredge *Harwood*, repaired, bolted, and calked the spud casings. On Bucyrus dredge, relagged main engine cylinders and built a platform around the bucket ladder. On steamer *McPherson*, built a bulkhead forward of the engines; put down shackle blocks; made two rope reels; repaired the rudders; built a covering over the steam pipe on the roof, and built bunks.

Refitted the woodwork of naphtha launch; made seven 12-foot tripods

for channel marks; made 50 rollers for use on cable road at Riverton, etc.

In addition to the items of machine and carpentry work enumerated above, many minor repairs were made to locks, buildings, boats, cars, locomotives, machinery, and tools.

Painting.—Two painters were employed continuously in repainting United States buildings, boats, barges, and other property.

Masonry and stonework.—Twenty cubic yards of ashlar masonry built in flume for sawmill; 33 cubic yards of coursed rubble masonry laid in tail race; 22 cubic yards rubble masonry laid in locomotive pits; 15 cubic yards concrete flooring put down in locomotive sheds; 25 cubic feet stone cut for foundation of engine lathe; mantels and grates reset in lock-keepers' houses at Locks A, B, 2, 3, 4, 5, 6, and 9; walls of Locks 6 and 7 repointed.

Miscellaneous.—Two hundred and twenty-four cubic yards of earth was placed behind the retaining wall below Lock 4, and the railroad track restored; 175 cubic yards of earth was used in grading on south side of Lock 4; 60 cubic yards of earth was used in grading at Lock 2, and 208 cubic yards at Lock 6; 8 slight leaks through embankments on sections 6, 7, 8, 9, 12, and 28 were closed; 530 linear feet of ditch of 4 square feet mean section was dug to drain seepage from bottom land on section 25; 125 cubic yards of sand was washed and floated on barges to Riverton.

A section gang was employed on the railway in cutting weeds and in general repairs to track. A logging gang was employed in cutting and hauling timber for sawing up at the mill for use in construction of snag boat and in repairs to floating plant.

Locomotives were employed in towing and miscellaneous hauling. Steamer *Colbert* was engaged in carrying freight, towing coal, making trips of inspection, and on several occasions assisting boats that had gone aground.

Sawmill.—Large quantities of lumber of various kinds are used annually in this district for making needed repairs to United States buildings and plant at the Muscle Shoals Canal and elsewhere. In the past few years the greatest difficulty has been experienced in getting lumber of proper lengths, and the prices paid have in most cases been out of all proportion to the value of lumber furnished. To obviate these difficulties authority was obtained at the close of the last fiscal year to build a sawmill at Muscle Shoals Canal for the use of the district at a total cost not to exceed $3,000, to be charged one-half to operating and care of Muscle Shoals Canal, and one-half to improving Tennessee River below Chattanooga.

Under this authority a saw and planing mill of 40 by 90 feet ground plan was built just above Lock 6, motive power and machinery were placed and the mill put into operation. Power is supplied by a 24-inch De Loach turbine under a working head of 13 feet. The machines now in place are a De Loach sawmill, No. 2, with 60-inch bottom saw and 30-inch top saw; a 6 by 24 inch six-roll wood planer, made by J. A. Fay & Co., of Cincinnati; a small circular saw for resawing and a swinging cut-off saw for cutting up slabs, etc. Power is transmitted by steel bevel gears from a vertical wheel shaft to a horizontal line shaft, and thence by belting and jack shaft to the several machines. All shafting is below the floor of the mill. A spur track has been extended from the canal railway to the rear of the mill, where an endless rope

conveyor delivers dust and refuse into dump cars, which are subsequently emptied into Shoal Creek.

The mill has been in operation about six months and has proved a valuable addition to the United States plant. The logs are purchased and hauled to the site of the mill or to some point on the bank of the canal. One hundred and seventeen thousand five hundred and thirty-three feet B. M. has been sawed during the year. Adding 10 per cent of the total cost of logs and sawing, for incidental expenses and repairs, and adding 6 per cent of first cost of mill, for depreciation of plant, there has resulted a saving to the United States of over $900 on the market price of the same quantity of lumber, or a saving of 38½ per cent.

Dry dock.—To furnish a place for repairing the extensive floating plant belonging to the United States in this district and to escape the exorbitant charges formerly made by the owners of ways on the Tennessee River whenever it became necessary to dock one of our boats, authority was obtained during the spring of 1895 to construct, at the Muscle Shoals Canal, a dry dock at a total cost not to exceed $3,000, to be charged one-half to operating and care of Muscle Shoals Canal and one-half to general improvement.

Under this authority the construction of a dry dock 70 by 150 feet in plan was begun on the north side of the canal between Locks 6 and 7. Two thousand three hundred and sixty seven cubic yards of stiff clay and stone were excavated from the site by dredging and 355 cubic yards by hand. Eighty-nine cubic yards of coursed rubble masonry was laid in Portland cement mortar, for the abutments of the gate, and 77 cubic yards of earth filled in behind the abutment. Thirty linear feet of drainage ditch was cleaned out and bull-pointed. There remains to be done the construction of the sills, drain culvert, and gate.

Shipyard.—During the year a clearing was made for use as a shipyard on the north side of the canal in the vicinity of the dry dock, and a tool house built thereon.

The following work was done during the year: Built complete two deck barges, Nos. 212 and 213 (100 by 25 feet); one flatboat (45 by 10 feet) with cabin, for use as a low water steamboat; one flatboat for calking; one 30-foot flatboat for handling drift at Lock 1, and three skiffs. Barge No. 202 (59½ by 15 feet) and barge No. 208 (80 by 20 feet) were rebuilt. Barge No. 209 was repaired and the construction of a snag boat for use on the river below Riverton was begun. New rakes and gunwales were built on the survey quarter boat.

In all cases where works of construction or repair were done at Muscle Shoals Canal for other sections of the river, the cost of this work has been charged to the proper appropriation.

For further details of work done in connection with operating and care of United States Muscle Shoals Canal, see appended report of Assistant Engineer W. A. McFarland (Appendix I).

Abstract of allotments.

November 28, 1890	$40,000.00	July 1, 1894	$63,772.63
July 1, 1891	31,792.04	July 1, 1895	64,793.11
July 1, 1892	45,232.90		
July 1, 1893	60,975.19	Total	306,565.87

Estimate of funds needed from appropriation for operating and care of canals and other works of navigation (indefinite), to be applied to current expenses in operating the Muscle Shoals Canal, from July 1, 1896, to June 30, 1897.

Amount required for fiscal year ending June 30, 1897	$65,000.00
Balance remaining from allotment of preceding year, exclusive of outstanding liabilities	2,292.54
Additional allotment required for fiscal year ending June 30, 1897	62,707.46

To be expended as follows:

One assistant engineer, at $200 per month	$2,400
One master mechanic, at $100 per month	1,200
One overseer, at $100 per month	1,200
One clerk, at $100 per month	1,200
Eleven lock masters, at $75 per month each	9,900
Eleven assistant lock masters, at $40 per month each	5,280
One locomotive engineer, at $60 per month	720
One engineer at machine shop, at $60 per month	720
One telephone lineman, at $50 per month	600
Two blacksmiths, at $75 per month each	1,800
One carpenter, at $80 per month	960
One overseer, at $80 per month	960
Thirty laborers, at $30 per month each	10,800
Dredging and towboat crews, $800 per month	9,600
Subsistence, $525 per month	6,300
Repairs of dredge, plant, material, and contingencies	11,360
Total for year	65,000

Detailed expenses incurred for operating and care of Muscle Shoals Canal during the fiscal year ending June 30, 1896.

Month.	Office and administration.			Operating, care, repairs, etc.		
				Locks A and B.		
	Salaries.	Supplies.	Total.	Labor.	Supplies.	Total.
1895.						
July	$275.00	$28.70	$303.70	$410.00	$101.55	$511.55
August	275.00	2.85	277.85	410.00	27.04	437.04
September	275.00	3.30	278.30	410.00	149.55	559.55
October	275.00	7.60	282.60	410.00	57.26	467.26
November	275.00	2.90	277.90	391.34	30.35	421.69
December	275.00	17.55	292.55	407.67	82.40	490.07
1896.						
January	275.00	1.20	276.20	410.00	33.26	443.26
February	275.00	.....	275.00	410.00	58.13	468.13
March	275.00	.....	275.00	410.00	43.32	453.32
April	275.00	.....	275.00	410.00	20.18	430.18
May	408.00	.....	408.00	307.50	6.07	313.57
June	502.00	1.50	503.50	314.00	15.12	329.12
Total	3,660.00	65.60	3,725.60	4,700.51	624.23	5,324.74

Month.	Operating, care, repairs, etc.				Grand total.
	Locks 1 to 9.				
	Labor.	Subsistence.	Supplies.	Total.	
1895.					
July	$2,650.93	$744.82	$500.25	$3,896.00	$4,711.25
August	3,892.43	510.50	649.28	5,052.21	5,767.10
September	3,954.90	331.84	545.31	4,832.05	5,669.90
October	3,351.21	329.79	692.52	4,373.52	5,123.38
November	4,211.45	867.86	470.36	5,549.67	6,249.26
December	4,239.93	585.68	773.18	5,598.79	6,381.41
1896.					
January	4,350.94	768.87	607.17	5,726.98	6,446.44
February	4,903.56	207.65	325.74	5,436.95	6,180.08
March	3,505.29	587.95	344.89	4,438.13	5,166.45
April	2,418.10	337.97	58.12	2,814.19	3,519.37
May	2,089.91	257.09	153.88	2,500.78	3,222.35
June	2,949.70	399.64	88.51	3,437.85	4,270.47
Total	42,518.25	5,929.66	5,209.21	53,657.12	62,707.46

Abstract of proposals for furnishing one year's supply of fresh meat at Muscle Shoals Canal, opened at United States Engineer Office, Chattanooga, Tenn., at noon, Monday, February 10, 1896.

No.	Name and address of bidder.	Beef, per pound.	Mutton, per pound.	Pork, per pound.
		Cents.	*Cents.*	*Cents.*
1	Chas. J. Halter, Florence, Ala	5	6	6
2	N. L. Crow, jr., Florence, Ala	6	6	6
3	Price & Blair, Florence, Ala	6	6	6
4	S. P. Merrill, Florence, Ala	8	8	8

Statement of traffic through the Muscle Shoals Canal during the calendar year ending December 31, 1895, compared with traffic during years ending December 31, 1892, 1893, and 1894.

Articles.	Year ending December 31—				Estimated value, 1895.
	1892.	1893.	1894.	1895.	
Steamers, number	60	95	37	35	.....
Barges, do	55	69	30	40	.....
Rafts, do	5	9	27	21	.....
Miscellaneous craft, do	12	35	40	21	.....
Tonnage, tons	4,476	12,812	5,891	4,578	.....
Lumber, do	962	3,543	3,127	1,598	$9,000
Cotton, do	225	59	.....	.....	.....
Grain, do	404	280	62	173	2,900
Flour, do	11	591	141	500	17,500
Oak extract, do	800	.....	.....	.....	.....
General merchandise, do	2,119	3,110	1,201	1,320	118,800
Logs, do	471	9,049	19,522	1,674	8,370
Iron, do	610	.....	.....	195	1,950
Coal, do	150	4	295	80	160
Total, do	5,782	16,636	24,348	5,540	158,680
Passengers, number	936	3,506	566	254	.....

The above is exclusive of supplies carried by Government steamers.

Only light-draft boats could be used during January and February, 1895, and during the last five months of the year there was no traffic.

Good navigation existed only five months.

Number of lockages, 974.

B B 3.

IMPROVEMENT OF HIWASSEE RIVER, TENNESSEE.

The Hiwassee River rises in the Blue Ridge Mountains in western North Carolina and northern Georgia, and flowing in a west-northwesterly direction enters the Tennessee River about 35 miles above Chattanooga and 148 miles below Knoxville. After breaking through the Smoky Mountain range and receiving the waters of the Ocoee, near Columbus, the Hiwassee becomes a stream of good capacity for navigation.

As early as 1830 the State of Tennessee made some minor improvements, but the work was only of temporary advantage. The act of Congress of June 23, 1874, authorized an examination of this river. The examination was made in September, 1874, under the direction of Maj. Walter McFarland, Corps of Engineers. (See Report of Chief of Engineers, 1875, pp. 809–813.) The principal obstructions were found to be rock reefs, gravel bars, snags, and overhanging trees, and are of

the same general character as those of the upper Tennessee, and the regimen of the river is equally permanent.

The project for the improvement was based on this examination and consisted in narrowing the waterway by wing dams at the shoal places and excavating rock reefs and gravel bars, so as to secure a navigable channel 40 feet wide and 2 feet deep at ordinary low water to Savannah Ford, about 43 miles from mouth of the river.

The original estimate submitted in 1875 was increased from 1878 to 1884, inclusive, to $36,500, which amount has been covered by the ten appropriations made for this improvement, viz:

Act of—		Act of—	
August 14, 1876	$10,000	July 5, 1884	$2,500
June 13, 1878	10,000	August 15, 1886	2,500
March 3, 1879	3,000	August 11, 1888	1,000
June 14, 1880	3,000	September 19, 1890	1,500
March 3, 1881	1,500		
August 2, 1882	1,500	Total	36,500

No appropriation has since been made.

The amount expended to June 30, 1895, including outstanding indebtedness, was $36,450.11.

The annual reports for 1892 and 1893 state that—

The work has resulted in a partial improvement of the lower river, securing an increased depth of channel and the removal of surface obstructions and overhanging trees.

The work was done at different times at the following obstructions: Matthew Shoals, McElrath Shoals, Sivils Shoals, Magills Islands, Blackbird Shoals, Graves Ferry and Shoals, Canefield Reef, Lasters Creek Shoals, Brindley Shoals, Denton Island Shoals, Boyd Shoals, Horseford Shoals, and Gamble Shoals. The Hiwassee is now navigable for steamboats from its mouth to Charleston, 21 miles, during the boating season on the upper Tennessee River. Above Charleston to Savannah Ford flatboats are used for transportation.

The work was first begun in June, 1877, at Matthew Shoals, and at intervals since, as each appropriation became available, efforts have been made to improve the channel at this the principal obstruction to navigation.

In order to distribute the fall at these shoals a part of the main dam extending from the right bank, opposite the lower island, was removed and a new spur dam, 167 feet long, built on a reef extending from the north bank, was constructed to back up the water. The effect has been very satisfactory to the extent of securing a reduction of the current's velocity opposite the lower island, but owing to high water and the exhaustion of the appropriation it was not practicable to complete the work. The other dams were straightened, raised, or strengthened where necessary; the banks also were protected by felling trees and placing brush in position, anchoring the same with stone. This resulted as desired in protecting the bank and deflecting the current to the opposite side of the river. A ringbolt was securely placed in position on end of lower dam to assist heavily laden ascending boats.

Work was suspended in September, 1892, the funds available for active operations being then exhausted.

Boats belonging to the Tennessee River Transportation Company ply upon this stream during the season of navigation. Small boats of about 100 tons capacity can navigate the Hiwassee River about eight months in the year.

The estimates of cost of improving the Hiwassee River have been appropriated and expended.

No work was done on the existing project during the fiscal year 1895–96, and there were no expenditures.

The Chief of Engineers, in a letter dated June 8, 1896, says:

As no appropriation has been made for continuing the improvement of this river since September 19, 1890, it can be properly assumed that, for the present at least, Congress has abandoned the improvement. The work will therefore be dropped from the list of duties with which you are charged. * * * A brief final report will also be submitted for the current fiscal year.

In accordance with these instructions, this will be the final report on this improvement.

Money statement.

July 1, 1895, balance unexpended	$72.93
July 1, 1896, balance unexpended	72.93
July 1, 1896, outstanding liabilities	23.04
July 1, 1896, balance available	49.89

Commercial statistics of Hiwassee River, Tennessee.

Articles.	Year ending December 31—				Estimated value, 1895.
	1892.	1893.	1894.	1895.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	
Grain	1,467	1,292	6,121	4,284	$72,185.40
Tan bark	320	275	.....	.....	.....
Live stock	165	65	188	150	9,375.00
Lumber	6,052	55	13	1,564	9,775.00
Flour	80	31	59	106	3,710.00
Sand	338	6	362	1,500	1,005.00
General merchandise	1,707	4,968	2,682	485	43,650.00
Cotton	.....	.....	14	14	1,960.00
Cotton seed	.....	.....	400	.....	.....
Iron ore	.....	.....	.....	91	109.20
Coal	.....	.....	.....	166	332.00
Hay	.....	.....	.....	250	2,000.00
Logs	.....	.....	.....	266	1,330.00
Total	10,129	6,692	9,839	8,876	145,431.60

Number of passengers transported (1895), 833.

List of steamboats (stern wheel) plying on the Hiwassee River, Tennessee.

Name.	Length.	Breadth.	Depth.	Net tonnage.
	Feet.	*Feet.*	*Feet.*	
R. T. Coles	118	24.6	4.2	134.91
Ocoee	51.5	12.5	1.6	19.18
J. P. Kindrick	111	20.0	3.5	138.71

B B 4.

IMPROVEMENT OF FRENCH BROAD RIVER AND LITTLE PIGEON RIVER, TENNESSEE.

The French Broad River is one of the largest tributaries of the Tennessee. The stream has its source in North Carolina on the western slope of the Blue Ridge, enters the State of Tennessee at Paint Rock, and after a course of 121 miles unites with the Holston River 4½ miles above Knoxville, thus forming the Tennessee River.

An appropriation was made by the State of Tennessee about 1840 for the purpose of improving the rivers of the section then known as the "East Tennessee District," and the improvement of Seven Islands Shoals of the French Broad River, about 30 miles below Dandridge, was begun

under direction of commissioners appointed by that State. The State of Tennessee also built some dams above Dandridge, but these, with the exception of a few repaired by the United States in 1881, have been removed during the progress of the work under the present project.

An examination was made of the French Broad in Tennessee under authority of act of Congress July 11, 1870, and the report upon it is to be found in the Report of Chief of Engineers for 1871, pages 491–494. A reexamination in Tennessee was ordered by Congress in act of March 3, 1875, "from its junction with the Holston at Knoxville to Leadvale, Tenn." The estimate made in 1871 was resubmitted with the report of 1876.

Below Leadvale, mouth of Nolichucky River, a distance of 90 miles, the river is impeded by the surface obstructions usually found in mountain streams. This stretch of River is exceptionally beautiful, broad, and adapted to navigation, especially below Dandridge about 50 miles. The fall being only about 1 foot per mile, the channel can be easily improved. From the junction of the Nolichucky River to the Tennessee State line, 31 miles, the French Broad is not susceptible of improvement except by slack-water navigation, the fall being 7 feet per mile.

The present project of improving the channel from mouth of river to Leadvale, about 90 miles, consists in removing surface obstructions, cutting down overhanging trees, and building wing dams where necessary, so as to permit the passage of boats drawing 2½ feet during the ordinary low-water season. Under this plan operations have been carried on at the most serious obstructions.

The following appropriations have been made by Congress for improving French Broad River in Tennessee, viz:

Act of—		Act of—	
June 14, 1880	$10,000	September 19, 1890	$10,000
March 3, 1881	3,500	July 13, 1892	15,000
August 2, 1882	5,000	August 14, 1894	7,000
July 5, 1884	3,500	June 3, 1896	5,000
August 5, 1886	6,000		
August 11, 1888	10,000	Total	75,000

The total amount expended to the close of the fiscal year ending June 30, 1895, including outstanding indebtedness, was $64,467.01. This expenditure has resulted in the improvement of ten of the principal obstructions below Dandridge by deepening and clearing the channel, removing fish traps, constructing and modifying wing dams, and revetting the banks when necessary. A list of these ten obstructions, with their distances below Dandridge and the work done at each to June 30, 1890, is given in the Annual Report of the Chief of Engineers, 1891, pages 2262, 2263.

The improvements made at Seven Islands Shoals have resulted in making this obstruction navigable for steamers at stages of the river when upstream navigation was heretofore impracticable. Before any work was done here by the United States it usually took a steamboat from one to one and a half days to go through, but now the passage can be made in forty-five minutes. At Bryant Shoal the modification and enlargement of the old wing dam and the removal of bowlders from the channel have greatly improved navigation. Great benefit has resulted from the improvement made at Jumping Moses Shoal, near mouth of the river, its dangerous condition having been greatly modified. At Hanging Rock Shoals the channel was changed from the north to the south side of Brabson Island. The new channel was cleared of snags, drift, etc., and some rock excavated. The old channel

was closed by a dam. Spur dams were built out from the island on the new channel side at intervals, and a longitudinal dam with similar spurs was built from the foot of the island in order to lengthen out the slope and diminish the velocity of the current.

At the beginning of the fiscal year work was in progress at Hanging Rock Shoals closing a break made by ice the winter before in the dam at the head of the island. The break was 90 feet long, and the current through it had cut out the sand and gravel to a depth of 8 feet. A tripod dam made of sycamore logs and 2-inch planks was placed across the break to prevent the current from washing away the stone dumped in to close the gap. The head of the island was heavily riprapped, as was also the bank of the island for 150 feet down to the first spur dam. The longitudinal dam at the foot of the island was extended 260 feet and five spur dams added with a total length of 490 feet. One of the spur dams was extended as a submerged dam across the channel and the bank opposite the spur dams was riprapped to prevent cutting. The improvement at Hanging Rock has been very successful. All danger to navigation has been removed, the depth in the channel is 3 feet, and the slope has been lengthened so that steamboats have now no difficulty in ascending the river.

On July 23 a part of the force was sent to Fains Island Shoals, 19 miles below. Owing to the limited amount of funds available, work here was confined to excavation of loose rock from the channel and to repairs on the old dams. While work was in progress a survey of Fains Island was made. Two and six-tenths feet were obtained in the channel where only 1.5 feet existed before.

On September 13 the whole fleet dropped down to Evans Island Shoals. Opposite the head of the island at Zimmermans Ford the bank was cutting badly. A crib 285 feet long of 8 by 8 inch by 12 to 16 foot white oak timber was built and sheeted with 1 by 6 inch planks driven to solid rock. Sand and gravel were used to fill the crib, as stone was very scarce and was needed to repair the spur dam which extends from the opposite bank. Two small spur dams were built at the head of Evans Island of loose stone excavated from the channel. This work assisted in removing a troublesome bar and increased the depth on it from 1.3 to 2.8 feet. At the foot of Evans Island three dams were repaired and loose rock excavated, increasing the depth at this point from 1.9 to 2.8 feet. Overhanging trees were cut in order to get additional width of channel. From Evans Island the fleet proceeded to Saffles Shoals. Two spur dams, 80 and 125 feet long, were built of loose rock excavated from the channel, increasing the depth from 1.8 to 2.9 feet. The fleet also worked at Underdowns Ferry, Seven Islands, Bowmans Shoals, and Pennyroyal Shoals, removing bowlders and snags from the channel, repairing dams, and cutting overhanging trees.

Work done on French Broad River during fiscal year ending June 30, 1896, with cost of same per unit, including labor, subsistence, and materials.

	Quantity.	Cost per unit.
Quarrying stone.....cubic yards..	2,013	$0.44
Riprap dam.....do....	2,642	.78
Excavation, channel, loose rock.....do....	873	.59
Excavation, channel, sand and gravel.....do....	376	.73
Riprap on bank.....do....	385	.37
Crib.....linear feet..	285	1.63
Trees cut from bank.....number..	4	1.16
Snags removed from channel.....do....	2	1.16

The amount expended during the fiscal year ending June 30, 1896, including outstanding indebtedness, was $5,182.17.

The improvement of the French Broad River, Tennessee, is of importance to the inhabitants along its banks, not only by reason of its increasing commerce, but because of its being constantly used as a highway for travel by the people themselves, a large number of passengers being carried by the small steamers that ply upon this stream. The commerce consists principally of marble, sand, logs lumber, forage, grain, live stock, wood, and general merchandise. The completion of the existing project of improvement will materially aid in the development of the mines, and will open a river highway for the transportation of the mineral wealth of the mountains and the products of the rich agricultural lands of the region drained by the river and its tributaries.

The estimate of $150,000 for improving the French Broad River from its mouth to Leadvale is insufficient to secure the 2-foot ordinary low-water navigation sought to be obtained under the project. The examinations heretofore made of the French Broad River were limited and incomplete, and are not sufficient whereon to base a revision of the estimate of 1871. If a radical improvement of the channel is to be undertaken, it is recommended that a detailed survey be made to obtain the data necessary to determine the cost of the work as projected, having in view its advantageous and economical prosecution.

LITTLE PIGEON RIVER, TENNESSEE.

This stream is formed by the junction of its east and south forks at Sevierville, Tenn., and flowing northwesterly for about 5 miles it enters the French Broad River about 32 miles above Knoxville.

An examination of Little Pigeon River was made under the provisions of river and harbor act of September 19, 1890. The channel was found to be obstructed by rock reefs and gravel shoals, the object of the proposed improvement at the estimate of cost submitted ($10,000) being to open up the river to navigation as far as Catlettsburg, about 2 miles, permitting the passage of the small steamers that ply upon the French Broad River, and occasionally during extreme high water to ascend to Sevierville, 5 miles from the mouth of the river. (See report printed as House Ex. Doc. No. 159, Fifty-first Congress, second session, and Report of Chief of Engineers, 1891, pp. 2287–2288.)

The river and harbor act of July 13, 1892, provided that of the $15,000 appropriated for improving French Broad River, Tennessee, $1,000 "may be used in removing bar or shoal in Little Pigeon River." This sum was allotted for the removal of the bar near the mouth of the river, described as the only bad shoal below Catlettsburg. No work was done nor expenditures made during the fiscal year ending June 30, 1893.

A working party was organized in October, 1893, and operations were begun and carried on for twenty days in connection with those in progress upon the French Broad River. To overcome the obstruction or shoal near the mouth of the river it was found desirable to excavate the channel at Gass Reef and to use the excavated material and loose rock in building riprap dam. The dam across the main island slough, 400 feet below the mouth of the river, backed the water into the Little Pigeon River. The channel through the bar at the mouth of the river changes after each high water, sand and gravel being deposited. Work was carried on from September 24 to October 16, 1895, by a working party from the French Broad River. The dams in the island chute were

repaired, the main channel was cleared out to deep water by hand, snags removed, and overhanging trees cut.

Summary and cost of work on Little Pigeon River, September 24 to October 16, 1895, inclusive.

	Quantity.	Cost per unit.
Quarrying stone.....cubic yards..	248	$0.52
Riprap dam.....do....	363	.80
Excavation, channel, loose rock.....do....	115	.46
Excavation, channel, sand and gravel.....do....	245	.41
Trees cut from bank.....number..	7	.68
Snags removed from channel.....do....	5	1.78

Total amount expended to close of fiscal year ending June 30, 1895, was $633.10.

The amount expended during the fiscal year ending June 30, 1896, including outstanding indebtedness, was $517.29.

For details of work on French Broad and Little Pigeon rivers see appended report of Superintendent R. R. Thacher (Appendix A).

The balance of the estimate for the proposed improvement is $8,000, of which $1,000 might be profitably expended during the next two fiscal years in repairing the dam above mentioned and in cutting trees.

Estimate of cost of improving French Broad River, Tennessee, from mouth to Leadvale	$150,000.00
Amount appropriated	73,000.00
Amount allotted for Little Pigeon River, acts of July 13, 1892, and August 17, 1894	2,000.00
Amount received, sale of steamer *McPherson*	900.00
Amount expended, including outstanding indebtedness, French Broad River	67,613.79
Amount expended, including outstanding indebtedness, Little Pigeon River	1,150.39

Money statements.

FRENCH BROAD RIVER.

July 1, 1895, balance unexpended	$5,568.38
Amount appropriated by act of June 3, 1896	5,000.00
	10,568.38
June 30, 1896, amount expended during fiscal year	5,050.94
July 1, 1896, balance unexpended	5,517.44
July 1, 1896, outstanding liabilities	131.23
July 1, 1896, balance available	5,386.21
Amount (estimated) required for completion of existing project	77,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	30,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

LITTLE PIGEON RIVER.

July 1, 1895, balance unexpended	$1,366.90
June 30, 1896, amount expended during fiscal year	517.29
July 1, 1896, balance unexpended	849.61
Amount (estimated) required for completion of existing project	8,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	8,000.00
Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.	

APPENDIX A.

REPORT OF MR. R. R. THACHER, SUPERINTENDENT.

HARRIMAN, TENN., *June 30, 1896.*

CAPTAIN: I have the honor to submit the following report on operations on the French Broad River for the fiscal year ending June 30, 1896.

At the beginning of the fiscal year work was in progress at Hanging Rock Shoals quarrying stone and building dams.

The work was begun here on account of a break in the main dam near the head of Brabsons Island, caused by the ice the previous winter. This break was 90 feet long and had cut through the sand and gravel to a depth of 8 feet, through which the water ran at such high velocity that it was found impossible to close the break without the aid of a temporary tripod dam. This dam was at once built around the break, using sycamore logs for tripods and 2-inch planks to breast the water. The tripods were first loaded with stone, then placed in position by the aid of a derrick boat. The planks were slid down the upper side of tripods, being held in position by the force of the water.

After the tripod dam was placed across the gap the current was slackened enough to enable the stone to remain in place, and the break was quickly closed.

The head of the island was heavily riprapped on both sides. On the left-hand side the riprapping was carried downstream 150 feet and tied to the first check dam. The tripods were left in position, as it would not pay to remove them.

The work then was confined to lengthening out the longitudinal dam at foot of island 260 feet.

To it were added five check dams, the total length of which was 490 feet. One of them was submerged across the channel to opposite bank.

The bank opposite the check dams was riprapped to stop any cutting that otherwise might take place.

The additional length to longitudinal dam and the extra check dams were built to lengthen out and distribute the fall.

The dams have been so located that no troublesome bars have formed from deposits.

The channel is slowly dredging and the deposit is carried behind the dams and into deep water below.

It was deemed advisable to begin operations at Fains Island, and on July 23 the fleet and working party were divided. Part remained at Hanging Rock Shoals to finish the work there and the other part was taken by steamer *Long* to Fains Island Shoals, a distance of 19 miles, where work was at once begun excavating loose rock from the channel and placing it on old dams. While the work was going on a survey of Fains Island was made.

The work resulted in obtaining a depth of 2.6 feet where 1.5 feet was formerly found at the shallowest places.

Owing to the limited amount of funds available, I was instructed to confine the work as closely as possible to removing loose rock from the channel, building up old dams that were in need of repairs, cutting overhanging trees, and removing snags on the way down from Fains Island to Pennyroyal Shoals, a distance of 41.4 miles.

The fleet and working party left Fains Island September 13, and dropped down to Evans Island, where work of a similar nature was carried on, besides the building of a crib at Zimmermans Ford 285 feet long of best white oak 8 by 8 inches 12 and 16 feet long, sheeted with 1 by 6 inch plank. The sheeting was sharpened and driven down to solid rock, and the crib filled with sand and gravel, as rock was very scarce. This crib was necessary in order to protect the bank, which was found to be cutting badly, and the channel was filling up and getting shallow. Then the check dam from the opposite bank was rebuilt.

The crib at Zimmermans Ford increased the depth from 1 foot to 3 feet, and the improvement is permanent so long as the rock dam opposite remains intact. Drift and ice greatly affect this dam, and it has been broken several times during the last five years. The excavation of loose rock at head of island and the building of two small dams of same had the effect of removing a troublesome bar, and increased the depth thereon from 1.3 feet to 2.8 feet.

The work at foot of island, which was excavation of loose rock and repairs of three dams, increased the depth there from 1.9 feet to 2.8 feet. Overhanging trees cut gave additional width to narrow places in channel. Width of channel at Evans Island Shoals is about 40 to 80 feet.

The fleet and working party dropped down to Saffles Shoals, where the channel was excavated of loose rock and the rock was used in constructing two dams at the foot of the shoals—one 80, the other 125 feet long.

This work has increased the depth from 1.8 feet to 2.9 feet. The channel is from 50 to 80 feet wide.

From Saffles Shoals the fleet went to Little Pigeon River.

Report on work there is given below.

The fleet and party left Pigeon River and dropped on down and out of the French Broad River, stopping at Underdouns Ferry, Seven Islands, Bowmans Shoals, and Pennyroyal Shoals, to remove bowlders from the channel, repair dams, cut overhanging trees, and pull snags.

The fleet left Pennyroyal Shoals on November 1, 1895, for Caney Creek Shoals, Tennessee River.

Detailed cost of work on French Broad River during fiscal year ending June 30, 1896.

Classification.	Quantity.	Cost.					Remarks.
		Labor.	Subsistence.	Material.	Total.	Unit cost.	
Stone quarried	*2,013	$748.06	$94.59	$45.83	$888.48	$0.44	For riprap dam.
Riprap dam	*2,642	999.63	137.21	40.83	1,177.67	.44	Building dam.
Dam in place	*2,642	1,747.69	231.80	86.66	2,066.15	.78	
Excavation, loose rock	*873	449.43	65.05	.....	514.48	.59	From channel.
Excavation, sand and gravel.	*376	235.62	39.32	.....	274.94	.73	Do.
Riprap in bank	*385	122.51	13.81	8.17	144.49	.37	
Building crib	†285	215.26	36.21	213.24	464.71	1.63	Bank protection.
Pulling snags	‡2	2.00	.32	.....	2.32	1.16	From channel.
Cutting trees	‡4	4.00	.64	.....	4.64	1.16	From bank.

*Cubic yards. †Linear feet. ‡Number.

LITTLE PIGEON RIVER.

The main obstruction consists of a gravel bar at the mouth of the river.

In 1891 the Government built a dam across the Main Island Slough about 400 feet below the mouth of the river. This dam backed the water into Pigeon River and helped in a small way to dredge a channel through the bar; but the channel changes after each high water and more or less sand is deposited there. The work was only of a temporary nature, being to rebuild the dams in the slough that had been somewhat broken by the ice the winter before.

The overhanging trees that interfered with boats getting into the river were cut down and the main channel was dredged out to deep water by hand.

Detailed cost of work on Little Pigeon River during fiscal year ending June 30, 1896.

Classification.	Quantity.	Cost.					Remarks.
		Labor.	Subsistence.	Material.	Total.	Unit cost.	
Stone quarried	*2.48	$93.20	$18.72	$17.43	$129.35	$0.52	For dams.
Riprap dam	*3.63	134.10	25.96	2.00	162.06	.45	Building dam.
Dam in place	*3.63	227.30	44.68	19.43	291.41	.80	
Excavation, loose rock	*1.15	45.00	8.56	.....	53.56	.46	From channel.
Excavation, sand and gravel.	*2.45	77.75	16.13	7.00	100.88	.41	Do.
Pulling snags	†5	7.50	1.41	.....	8.91	1.78	Do.
Cutting trees	†7	4.00	.77	.....	4.77	.68	From banks.

*Cubic yards. †Number.

Respectfully submitted.

R. R. THACHER, *Superintendent.*

Capt. DAN C. KINGMAN,
Corps of Engineers, U. S. A.

Commercial statistics of French Broad River, Tennessee.

Articles.	Year ending December 31—				Estimated value, 1895.
	1892.	1893.	1894.	1895.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	
Grain	.....	8,600	28,933	9,814	$165,365.90
Lumber	.....	2,200	5,733	7,414	46,337.50
Flour	.....	300	733	506	17,710.00
Live stock	.....	580	453	480	30,000.00
Wood	.....	150	.....	400	400.00
General merchandise	12,500	5,595	13,546	10,311	927,990.00
Iron ore	.....	.....	.....	66	79.20
Hoop poles	.....	.....	.....	12	60.00
Coal	.....	.....	.....	566	1,132.00
Hay	.....	.....	.....	1,150	9,200.00
Logs	.....	.....	.....	7,041	35,205.00
Shingles	.....	.....	.....	5,000	100,000.00
Brick	.....	.....	.....	138	483.00
Total	12,500	17,425	49,398	42,898	1,333,962.60

Number of passengers transported (1895), 4,733.

List of steamboats (stern-wheel) plying on the French Broad River, Tennessee.

Name.	Length.	Breadth.	Depth.	Net tonnage.
	Feet.	*Feet.*	*Feet.*	
Telephone	93	19	2.6	97.47
Lucille Borden	86	14	2.5	55.32
C. M. Fouche	96	14	3	61.12
Tallassee	60	12	2	22.16
Onega	104.6	18	2.5	74.77

B B 5.

IMPROVEMENT OF CLINCH RIVER, TENNESSEE.

The Clinch River rises in the Cumberland Mountains, in southwestern Virginia, and flows in a southwesterly direction, generally parallel to the Holston River, and empties into the Tennessee River at Kingston, Tenn., 104 miles above Chattanooga and 79 miles below Knoxville, the length of its course in Tennessee being about 230 miles.

Between 1830 and 1845 work was done by the State of Tennessee, but it resulted in little or no advantage to navigation. The country drained by this river, about 1,436 square miles, is mountainous and has very meager transportation facilities.

Under authority of act of Congress approved March 3, 1875, examination of the river was made both in Virginia and Tennessee. Osborn Ford, Virginia, about 35 miles northeast of the Tennessee line, is regarded as the head of high-water navigation on the Clinch River. It has no low-water navigation. (See Report of Chief of Engineers, 1876, pp. 736–747.) An examination of the Clinch River from Nash Ford, Virginia, to Haynes (or Walker Ferry), Tenn., a distance of about 161 miles, was made in 1880. (See Report of Chief of Engineers, 1881, pp. 1864–1867.) The original project, submitted in 1876, provided only "to improve the high-water navigation of this river, so that there shall be less difficulty and danger in bringing out cargoes, and so that rain tides of 3 or 4 feet may be made use of for boating purposes." This was estimated at $26,400. In 1881 the engineer officer in charge reported that he hoped to attain a permanent increase of depth of water in channel by blasting rock, etc., "securing for about 146 miles of the lower river at ordinary low water, from its mouth to Clinton, about 2 feet, and from Clinton to Walker Ferry (Haynes) about 1½ feet," adopting the low-water channel, which in 1876 had been simply suggested as

a channel that might be found practicable after a careful survey, and thus modifying the then existing project, but without increasing the original estimate, which was simply for high-water navigation, by the cost of the channel projected. In 1885 the estimate was increased to $50,000, "because it had been found necessary to make the channel from two to three times the width thought sufficient when the original estimates were made," but the estimate was not increased, although the proposed low-water navigation instead of the high-water navigation was adopted as part of the present project; therefore the balance of the original estimate as modified and remaining unappropriated, $8,500, is manifestly inadequate to complete the work as projected.

The examinations made of the Clinch River are not sufficient whereon to base an estimate of the cost of the projected low-water channel below Walker Ferry, but if radical improvement is to be undertaken it is recommended that a detailed survey be made to obtain the data necessary to determine the cost, having in view an advantageous and economical prosecution of the work.

Above Walker Ferry to the Tennessee State line, about 85 miles, the only projected improvement is to reduce the ledges and remove loose rock, etc., sufficiently to assist flatboat navigation and rafting during "rain tides."

The following appropriations have been made for this improvement:

Act of—		Act of—	
June 14, 1880	$10,000	September 19, 1890	$4,000
March 3, 1881	3,000	July 13, 1892	4,000
August 2, 1882	3,000	August 17, 1894	2,500
July 5, 1884	5,000		
August 5, 1886	5,000	Total	41,500
August 11, 1888	5,000		

The total amount expended to June 30, 1895, including outstanding indebtedness, was $36,859.20; the general results attained by this expenditure are that the reefs have been reduced, many snags and overhanging trees removed, and several strong heavy wing and longitudinal dams built, thus securing a passable channel at stages of the water 2 or 3 feet lower than before the improvement was begun.

Above Hayne (or Walker Ferry) special advantages were secured about ten years ago at Hunter Shoals, Sycamore Shoals, Hopson Shoals, and Straight Shoals.

Below Walker Ferry (Hayne) important work has been done at Black Shoals and Bletcher Shoals; at Cloud Shoals seven dams have been built and a heavy dam at Hibb Shoals, which, with the rock excavation in channel, have lessened the dangers to navigation. At Llewellyn Shoals the improvements completed consist of reducing projecting rocky points, removing snags, sand, and gravel from the channel, completing wing dams, and constructing dam 190 feet long about 324 feet below Moore Ferry or Ford. Safe navigation at these shoals is now reported possible at a stage of water from 1 to 1½ feet lower than before the work done in 1892 was begun. At Young Island the fish-trap dam was taken from the chute south of the island, but more work is necessary to confine the water to one channel for the floating of logs to the mills below the island.

In July, 1892, partial examinations were made below the mouth of Powell River, and in October below the mouth of Emory River, having in view the ascertaining, in a general way, of what work is necessary to be done to improve the channel to the extent of securing a navigable depth of 2 feet at ordinary low water.

No channel work was practicable during the fiscal year 1894 until

November, 1893; a little work was then done near Given Ford, about one-half mile below mouth of Emory River; 60 cubic yards of loose rock was removed from channel and placed in riprap dams at this point; cold weather and high water setting in, all work was necessarily suspended.

No work was done on existing project during the fiscal year 1895–96.

The amount expended during the fiscal year, including outstanding indebtedness, was $288.84.

Having reference to navigation and commerce upon the lower Clinch River the Annual Report for 1893 states:

> The section of the river below Clinton, a distance of about 70 miles, is practicable for steamboat navigation during the higher stages of the river, and to increase the length of the season of navigation the present project contemplates the construction of wing dams and other channel work at the most troublesome obstructions. The principal navigation at present consists of logs and zinc ore. Immense tracts of uncut timber still remain in the country adjacent to this stream, and will for a long time to come require its channel as a means of transportation. The product of the zinc mines is brought down from time to time in flatboats to the reducing works at Clinton. These ore deposits are reported as being very extensive and practically dependent upon the river for transportation.
>
> The Loomis & Hart Manufacturing Company, of Chattanooga, Tenn., reports that about 78 per cent of the logs reaching Chattanooga are run out of the Clinch and its tributaries—the Powell and Emory rivers.

Estimate for improving Clinch River, Tennessee, as modified in 1885	$50,000.00
Amount appropriated	41,500.00
Amount expended, including outstanding indebtedness	37,056.36

Money statement.

July 1, 1895, balance unexpended	$4,640.80
June 30, 1896, amount expended during fiscal year	260.00
July 1, 1896, balance unexpended	4,380.80
July 1, 1896, outstanding liabilities	* 62.84
July 1, 1896, balance available	4,317.96
Amount (estimated) required for completion of existing project	8,500.00
Amount that can be profitably expended in fiscal year ending June 30, 1898	8,500.00

Submitted in compliance with requirements of sections 2 of river and harbor acts of 1866 and 1867 and of sundry civil act of March 3, 1893.

COMMERCIAL STATISTICS OF CLINCH RIVER, TENNESSEE.

Articles.	Year ending December 31—				Estimated value, 1895.
	1892.	1893.	1894.	1895.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	
Grain	.....	94	1,290	1,276	$21,500.60
Flour	.....	10	110	71	2,485.00
Iron ore	.....	5	44	766	919.20
Lumber	.....	160	201	1,844	11,525.00
Live stock	.....	.....	80	1	62.50
General merchandise	.....	339	11,207	840	75,600.00
Logs	25,000	.....	.....	61,473	307,365.00
Cotton	.....	.....	.....	13	1,820.00
Coal	.....	.....	.....	466	932.00
Hay	.....	.....	.....	2,150	17,200.00
Total	25,000	608	13,932	68,900	439,409.30

Number of passengers transported (1895), 1,048.

List of steamboats (stern wheel) plying on Clinch River, Tennessee.

Name.	Length.	Breadth.	Depth.	Net tonnage.
	Feet.	*Feet.*	*Feet.*	
Key City	80	16	3	59.45
Kingston	55	11	3.7	37.80
Clinton B. Fisk	100	18	3.4	78.89

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